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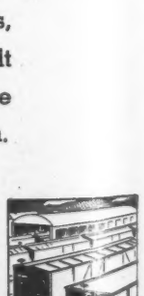


RAILWAY
MECHANICAL ENGINEER

Designing for

High Tensile Steels

By H. M. Priest

This paper presents data to assist the designer in the correct utilization of these steels in light-weight rolling-stock construction

HIGH-TENSILE steels have made a notable contribution to the recent developments in light-weight railroad rolling stock which have captured the imagination of the public and stimulated the interest of engineers and manufacturers. The most obvious opportunities for economical and successful applications of such steels lie in the field of movable structures, such as passenger and freight cars, trucks, buses, street cars, mine cars and travelling cranes, but the products in many other fields are now being subjected to critical study in the endeavor to determine what possibilities for weight reduction are to be found there.

Any analysis of a specific problem should give attention to first cost, maintenance, depreciation and operating cost of the structure and in some cases to increased revenue from the additional "pay load" which may be permitted by the decrease in dead weight.

While these matters are important they can only be evaluated after a design has been prepared. This paper is concerned more particularly with this latter phase of the problem and aims to present some observations on designing for high-tensile steels which may be helpful to engineers in their investigations. Long experience with ordinary carbon steels of structural grade furnishes a natural background against which to make comparisons and to form judgments. Such comparisons will be facilitated by the arrangements of the text.

The working unit stresses are the principal factors in the design of any structure since they determine the sizes of the material, although the limitations imposed by such an item as a clearance diagram may modify the choice of the most economical sections. In order to make the paper of broad application, the formulae throughout the text have been kept in general symbols for which may be substituted the values of the unit stresses which pertain to the structure under consideration.

The design which serves as the basis for comparison will be referred to as the "basic design" in contrast with the designation "new design" which will be applied to the comparative design. The subscript *1* indicates a function or term for the basic design, while functions or terms for the new design are written with the subscript *2*. General formulae, applicable to all cases, are written without subscripts.

The selection of working unit stresses depends upon the class of structure to be designed and the character and magnitude of the loads to be carried. Most branches of engineering have adopted unit stresses for carbon steel which experience has shown will produce satisfactory structures. No attempt will me made to specify the unit stresses to be used with high-tensile steels when applied in particular fields of construction, but it is hoped that the succeeding discussion will prove definitely helpful to designing engineers.

It is quite generally the accepted viewpoint to regard the yield-point stress as indicating the useful strength of a structure. When this stress is reached the deformations increase rapidly accompanied by little or no increase in loads, permanent sets come into existence and the distorted structure may be said to have reached the end of its effectiveness. In other cases, the modulus of elasticity is often the controlling factor when a member will fail in buckling, either as a whole or locally in a portion of it.

Before entering upon the discussion of high-tensile steels it may be interesting to review the material and design specifications covering carbon steels of structural grade in three representative fields. Table I lists the physical requirements of the A. S. T. M. specifications for steel in bridges and buildings and those of the Association of American Railroads for structural steel. The brief abstracts of working unit stresses are from the design specifications of the American Railway Engineering Association, American Institute of Steel Construction and the Association of American Railroads and have been tabulated below the appropriate material specifications.

The factors of safety have been computed on the basis of the required minimum yield points. It will be noted that the material specifications for steel for bridges and buildings state that the yield point shall not be less than 33,000 lb. per sq. in. The A. A. R. specifications for structural steel set no such secondary minimum value for the yield point, but it does not appear reasonable to use one-half of 50,000, or 25,000 lb. per sq. in. as the minimum value when computing the factor of safety in car design. It is the experience of the mills that steel up to ¾ in. in thickness will have a minimum yield point of 28,000 to 29,000 lb. per sq. in. when ordered to the A. A. R. specifications. Plates of around ¼ in. in thickness will have a minimum yield point of about 33,000 lb. per sq. in. For the purpose of computing the factors of safety shown in Table I for the unit stresses of the A. A. R., the value of the minimum yield point has been taken as 29,000 lb. per sq. in. The seemingly higher factor of safety for compressive unit

stresses as compared to those for tension is due to the fact that the column formulae contain an allowance of 25 per cent for eccentricity, thus making the factor of safety equal to 2.20 divided by 1.25, or 1.76. This subject is treated more fully under the section dealing with compression.

A word of explanation may be desirable regarding the factors of safety for the shearing values. Tests have shown that the yield point in shear for steels of this grade is about 62.5 per cent of the tensile yield point. This factor has been used to obtain the results in the table.

Properties of High-Tensile Structural Steels

In the selection of a high-tensile steel there are several low-alloy steels from which to choose. Consideration should be given to a number of factors, the more important of which will be briefly discussed.

Tensile Strength—Steels suitable to a wide range of structure in which weight reduction is sought will have ultimate tensile strengths ranging up to about 100,000 lb. per sq. in.

Yield Point—The yield point is of prime importance for the reason that it is the strength upon which working unit stresses are generally based. The ratio of yield-point strength to ultimate strength in tension is about 0.50 to 0.60 for structural carbon steel. This ratio will increase for high-tensile steels, ranging up to 0.70 or 0.75. A narrow spread between yield point and ultimate strength is apt to be accompanied by a lowering of the ductility, for which reason it is probably well to limit the maximum yield point to about 75 per cent of the ultimate strength.

Ductility—It is often true that the ductility of steel decreases with increase of tensile strength. For steels above 100,000 lb. per sq. in. in tensile strength, the ductility might be reduced to a point where difficulties would be met in pressing and forming the steels. Even at strengths below this limit it has been found that the greater stiffness of these steels requires an increase in the radii of fillets for cold-pressing operations. A radius of two to three times the thickness of the material should give satisfactory results. Ductility is a property which enables the steel to yield at points of stress concentration and thus effect a redistribution of the stress without failure occurring locally.

Fatigue Strength—The fatigue strength or endurance limit becomes important when the structure, or parts of it, are subjected to varying or alternating stresses. Working unit stresses should then be based upon the fatigue strength or the yield point, whichever is the lesser of the two.

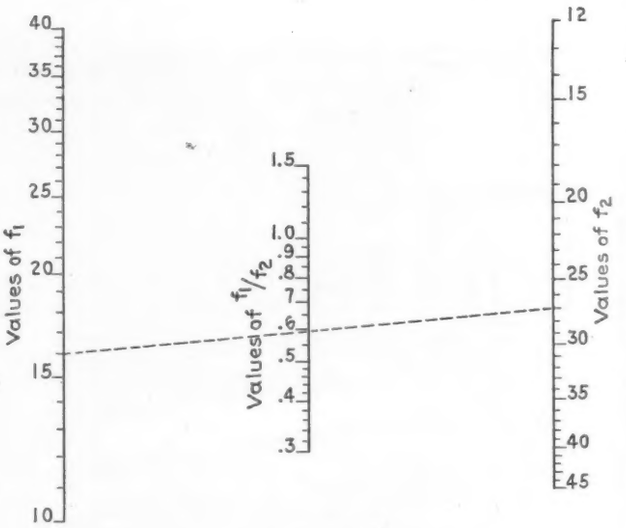


Fig. 1—Ratio of $\frac{f_1}{f_2}$

Impact Strength—Impact strength is usually determined from an Izod or Charpy test and is expressed as the number of foot-pounds of energy absorbed by a notched specimen when broken by the blow of a weighted pendulum. The test is supposed to indicate the resistance of the steel to shocks but there is no direct correlation with other properties of the steel. However, the tests have merit in comparing the relative impact strengths of the steel at various temperatures or after different heat treatments.

Corrosion Resistance—The use of high-tensile steel permits of reductions in the thicknesses of material and in some cases thereby introduces the question of the life of the thinner material under the action of corrosion. The body sheets of a hopper car are an excellent example of the problem of the effective life of the steel. In several recent developments of light-weight hopper cars a steel has been selected which has increased resistance to corrosion over that possessed by copper-bearing carbon steel.

Workability—Under this heading may be classed the performance of the steels in the various shop operations of cutting, punching, drilling, reaming, milling, planing, hot and cold pressing and flanging. These items are somewhat affected by the additional strength and stiffness of the high-tensile steels. As compared to shop practice with carbon steel of structural grade it will be found that the maximum thickness of material for

Table I—Specifications of Carbon Steels

	A.S.T.M. A7—34 Bridges	A.S.T.M. A9—34 Buildings	A.A.R. M116—34 Structural
Material specifications			
Tensile strength, lb. per sq. in.	60/72,000	60/72,000	50/65,000
Yield point, min.	0.5 T.S.	0.5 T.S.	0.5 T.S.
But not less than	33,000	33,000	.....
Elong. in 8 in., min., per cent	1,500,000 / T. S.	1,400,000 / T.S.	1,500,000 / T.S.
Elong. in 2 in., min., per cent	22	22	25
Design specifications	A.R.E.A. Railway Bridges, 1935	A.I.S.C. Buildings, 1934	A.A.R. Box Cars, 1929
Tension (net sec.), lb. per sq. in.	18,000	18,000	16,000
Tension (bending), lb. per sq. in.	18,000	18,000	16,000
Compression	Pin ends $\frac{P}{A} = 15{,}000 - \frac{1}{3}\left(\frac{L}{r}\right)^2$	$\frac{P}{A} = \frac{18{,}000}{1 + \frac{1}{18{,}000}\left(\frac{L}{r}\right)^2}$ max. = 15,000	Fixed ends $\frac{L}{r} < 40 \quad \frac{P}{A} = 16{,}000$ Rankine formula: $S = \frac{P}{A}\left[1 + \frac{1}{25{,}000}\left(\frac{L}{r}\right)^2\right]$
Shear on webs, lb. per sq. in.	11,000	12,000	12,000
Factors of safety for	Min. Y.P. = 33,000	Min. Y.P. = 33,000	Min. Y.P. = 29,000
Tension	1.83	1.83	1.81
Compression $\left(\frac{L}{r} = 0\right)$	2.20*	2.20	1.81
Shear	1.87	1.72	1.51

* Includes 25 per cent for eccentricity.

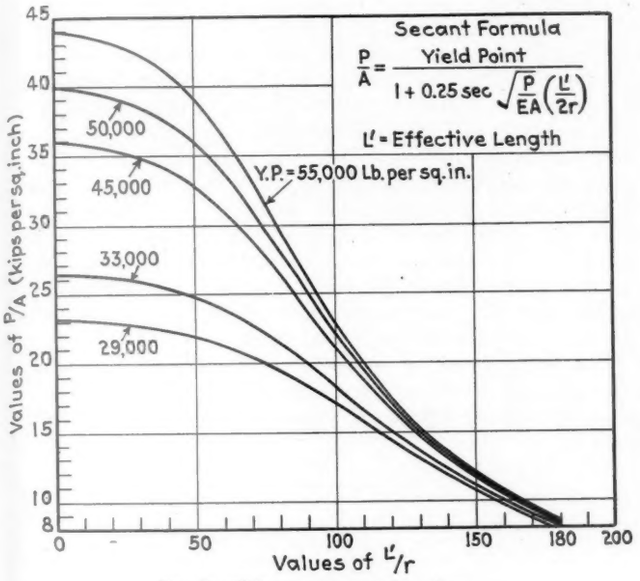


Fig. 2—Ultimate compressive stress

punching is somewhat less for high-tensile steel. The rate of speeds for drills and reamers may have to be reduced, perhaps by 25 per cent or 30 per cent. Hot pressing is practically the same as for carbon steel but in cold pressing operations it is necessary to use generous radii on all fillets. Due to the greater stiffness of a high-tensile steel it will be found desirable to decrease somewhat the speed of pressing in order to allow the steel sufficient time to adjust itself in the dies.

Weldability—The developments in the field of welding have opened up new possibilities in all lines of construction. Definite economies of weight may often be achieved by the application of welding to the fabrication. It is well to point out that the designer must change from the viewpoint of his past experience with riveted work if he is to make real progress with welding. In the light of present-day trends, it is essential that the high-tensile steels should have good welding qualities.

General Considerations—There are other properties which would be of special interest in particular fields of application, such as the coefficient of expansion, thermal conductivity, magnetic permeability, hardness and resistance to abrasion, but those given above are the principal ones. An extended discussion of each factor has not been attempted—simply an enumeration with brief comments. For more detailed information about high-tensile steels and their applications the reader is referred to a paper entitled "Modern Steels and Weight Reduction" by J. C. Whetzel, which was presented at the general meeting of the American Iron and Steel Institute on May 23, 1935.

For simplicity of treatment, the subject of design will be divided into sections, beginning with a discussion of "Tension." Clarity in the development of the subsequent topics requires the use of a factor of safety. The value selected in each case serves simply as an illustration and should not be taken as the writer's recommendation. As previously stated, the reader is expected to make his own selection to fit the particular problem under consideration.

Tension

The working unit stress for tension members is commonly based upon the yield point of the steel, using an appropriate factor of safety. By reference to Table I it will be seen that the grade of structural carbon steel which is specified by the Association of American Railroads has the following physical properties:

Tensile strength.....50,000 to 65,000 lb. per sq. in.
Yield point.....½ of tensile strength, min.

The working unit stress in tension for car construction is usually specified as 16,000 lb. per sq. in., which

Table II

Minimum yield point, lb. per sq. in.	Working unit stresses, lb. per sq. in. Factor of safety = 1,813	In round numbers
29,000	16,000	16,000
33,000	18,200	18,000
45,000	24,810	25,000
50,000	27,600	27,000
55,000	30,340	30,000

gives a factor of safety equal to 29,000 divided by 16,000, or 1.813, when referred to the minimum yield point of 29,000 lb. per sq. in. previously proposed as a basis for the computations in Table I. The application of this factor of safety to several high-tensile steels will give the results shown in Table II.

The required cross-sectional area of a tension member is readily derived from the well-known formula:

$$A = \frac{P}{f} \qquad (1)$$

A = Required area, sq. in.
P = Total stress, lb.
f = Unit stress in tension, lb. per sq. in.

The relation between the areas required with different unit stresses will now be derived.

For the basic design:

$$A_1 f_1 = P$$

For the new design:

$$A_2 f_2 = P$$

From which

$$A_2 = \frac{f_1}{f_2} \times A_1 \qquad (2)$$

The nomograph in Fig. 1 solves graphically for the value of the ratio f_1/f_2. Let the basic unit stress, f_1, equal 16,000 lb. per sq. in. and the new stress, f_2, equal

Table III—Values of $\frac{f_1}{f_2}$

f_2, lb. per sq. in.	Values of f_1, lb. per sq. in. 12,000	16,000	18,000
16,000	.750	1.000	.....
18,000	.667	.889	1.000
20,000	.600	.800	.900
24,000	.500	.667	.750
25,000	.480	.640	.720
26,000	.462	.615	.692
27,000	.445	.593	.667
28,000	.429	.572	.643
29,000	.414	.552	.621
30,000	.400	.533	.600

27,000 lb. per sq. in. Lay a straight edge across the nomograph, connecting the point 16 for f_1 with the point 27 for f_2 as indicated by the dotted line. Where it crosses the middle vertical line, read the value of .59 for f_1/f_2. Then $A_2 = .59A_1$ which shows a saving of 41 per cent in area (hence in weight) when a steel is used which permits of a working unit stress of 27,000

Table IV—Angle Tension Members

(For total stress = 105,000 lb.)

Construction	Unit stress, lb. per sq. in.	Required area, sq. in.	Number—Size, in.	Net area, sq. in.	Gross area, sq. in.	Ratio
Riveted	16,000	6.56	2—6 x4 x⅜	6.56	7.22	1.00
	24,000	4.38	2—3½x3 x7/16	4.52	5.30	.73
	27,000	3.89	2—4 x3½x5/16	3.96	4.50	.62
	30,000	3.50	2—4 x3 x5/16	3.64	4.18	.58
Welded	16,000	6.56	2—5 x3 x7/16	...	6.62	1.00
	24,000	4.38	2—3 x2½x7/16	...	4.42	.67
	27,000	3.89	2—3½x3 x5/16	...	3.86	.58
	30,000	3.50	2—3½x2½x5/16	...	3.56	.54

Ratios in last column are those of gross areas to that for unit stress=16,000

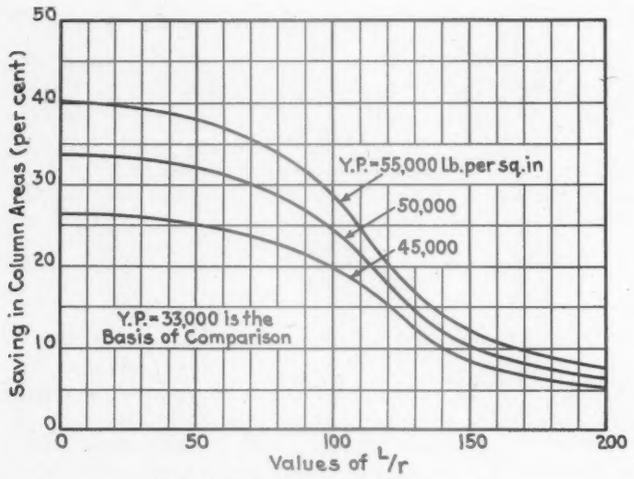


Fig. 3—Comparison of column areas

lb. per sq. in. Table III lists the values of the ratio for a few selected values of f_1 and f_2.

Table IV is a tabulation of the required sizes of angle tension members for several different unit stresses. Two methods of construction are given—one for riveted work in which the net section of the angles governs, the other for welded work when the full gross section of the angles is effective. Under the column headed "Ratio" are the ratios of the areas referred to that for a unit stress of 16,000 lb. per sq. in. Comparing these ratios to the theoretical values in Table III it will be seen that the full saving is not quite realized with riveted construction but is met with welded work. The table also brings out the weight saving that can be effected by welding.

Compression

In 1923 the American Society of Civil Engineers authorized a Special Committee on Steel Column Research. Engineers will find its first and second progress reports and final report[1] of invaluable assistance in the study of columns and compression members.

The following extracts are quoted from the "Summary and Conclusions" at the end of the final report:

1—Columns tested with hinged ends and eccentric loads give results both as to deflection and distribution of stress that agree very closely with the theoretical analysis within the limits of elasticity of the material.

2—The ultimate strength of such columns agrees fairly well with the theoretical strength based upon the yield point of the material and assuming elastic conditions up to the point of failure.

5—A rational column formula can best be constructed on the basis of the theoretical formula for eccentrically loaded columns, using values of eccentricity and free length of column derived from truss analysis. The yield point strength of the material may be used in a formula for ultimate strength. The formula representing ultimate strength will then be,

$$\frac{P}{A} = \frac{\text{Yield Point}}{1 + a \sec \sqrt{\frac{P}{AE}} \left[\frac{L'}{2r} \right]}$$

in which a = eccentric ratio to be used, and L' = free length of column.[2]

6—For columns bent in single curvature, an eccentric ratio of $a = 0.25$, to include both crookedness and eccentric application of load and a free length of three-fourths the full length for riveted connected members are suggested as reasonable values for ordinary trusses.

Fig. 2 gives the curves for ultimate strength of columns for several values of yield point, using the recommended eccentric ratio of 0.25. For riveted ends, such as occur in truss members, the effective length L' is to be taken as equal to 0.75 of the actual length L. Similarly for pin ended members, $L' = 0.85L$. It is quite evident from the chart that for the higher values of L'/r the values of P/A for all yield points approach equality, since the values approach the Euler load which is dependent upon the modulus of elasticity. This is due to the fact that the modulus of elasticity is practically the same for various grades of steel.

For the purpose of reducing the formula for ultimate strength to a working unit-stress basis a factor of safety of 1.80 will be used. The column formula then becomes:

$$\frac{P}{A} = \frac{\text{Yield Point}}{1.80} \Big/ \left(1 + 0.25 \sec \sqrt{\frac{1.80P}{AE}} \left[\frac{L'}{2r} \right]\right) \quad \ldots\ldots (3)$$

This so-called "secant formula" does not readily lend itself to rapid solution and the writer has derived the simpler formulae in Tables V and VI which do not deviate more than two per cent from the values given by Equation (3).

While these formulae are based on a factor of safety of 1.80 it is a simple matter to convert them to any other factor of safety by multiplying by 1.80 and dividing by the desired factor. For example, let it be required to derive a column formula for pin ends with a yield point of 33,000 lb. per sq. in. and a factor of safety of 1.76:

$$\text{For } \frac{L}{r} = 0 \text{ to } 140 \qquad \frac{P}{A} = \frac{1.80}{1.76}\left[14{,}670 - .316\left(\frac{L}{r}\right)^2\right]$$

$$= 15{,}000 - .323\left(\frac{L}{r}\right)^2$$

Table V—Column Formulae, Riveted Ends

Yield point, lb. per sq. in.	Limiting values $\frac{L}{r}$ of	Working unit stress, lb. per sq. in.
55,000	0–120	$\frac{P}{A} = 24{,}500 - .690\left(\frac{L}{r}\right)^2$
	120–200	$\frac{P}{A} = \frac{24{,}500}{.52 + \frac{1}{12{,}390}\left(\frac{L}{r}\right)^2}$
50,000	0–130	$\frac{P}{A} = 22{,}200 - .563\left(\frac{L}{r}\right)^2$
	130–200	$\frac{P}{A} = \frac{22{,}200}{.52 + \frac{1}{13{,}740}\left(\frac{L}{r}\right)^2}$
45,000	0–140	$\frac{P}{A} = 20{,}000 - .454\left(\frac{L}{r}\right)^2$
	140–200	$\frac{P}{A} = \frac{20{,}000}{.52 + \frac{1}{15{,}300}\left(\frac{L}{r}\right)^2}$
33,000	0–160	$\frac{P}{A} = 14{,}670 - .246\left(\frac{L}{r}\right)^2$
	160–200	$\frac{P}{A} = \frac{14{,}670}{.52 + \frac{1}{20{,}780}\left(\frac{L}{r}\right)^2}$
29,000	0–165	$\frac{P}{A} = 12{,}900 - .192\left(\frac{L}{r}\right)^2$
	165–200	$\frac{P}{A} = \frac{12{,}900}{.52 + \frac{1}{23{,}450}\left(\frac{L}{r}\right)^2}$

Formulae are based on the "Secant" Formula.
Factor of Safety = 1.80.

[1] For first progress report, see A.S.C.E. Transactions, Vol. 89; for second progress report, see A.S.C.E. transactions, Vol. 95; for the final report, see A.S.C.E. Transactions, Vol. 98.

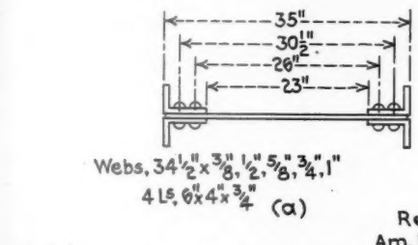
[2] The eccentric ratio a equals ec/r^2, in which e = the eccentricity of the load, c = distance from the neutral axis to the extreme fibre, and r = radius of gyration of the section. When there is a known eccentricity of loading, the ultimate strength of the column may be calculated by substituting the proper values in the expression for $a = ec/r^2$.

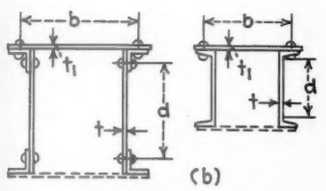
This is the factor of safety used by the American Railway Engineering Association in its Specifications for Steel Railway Bridges and results in the formula given in Table I, with which the above formula is seen to be in practical agreement.

$$\text{For } \frac{L}{r} = 140 \text{ to } 200 \qquad \frac{P}{A} = \frac{1.80}{1.76}\left[\frac{14670}{.52 + \frac{1}{16190}\left(\frac{L}{r}\right)^2}\right]$$

$$= \frac{15000}{52 + \frac{1}{16190}\left(\frac{L}{r}\right)^2}$$

Following the procedure of comparing the results to be obtained by the use of high-tensile steels with those





Requirements Am. Ry. Eng. Assoc'n.

Yield Point	Max. Allow. Value	
	Webs d/t	Covers b/t_1
33,000	32	40
45/50,000	28	36

Fig. 4—Unsupported plates in compression members

of ordinary carbon steel, the diagram of Fig. 3 gives the percentage in saving of column area, based upon the averages for pin and riveted ends, as derived from the formulae in Tables V and VI.

For example, at $L/r = 60$ the formulae give the following values of P/A for yield points of 33,000 and 55,000 lb. per sq. in.:

Yield point	Values of $\frac{P}{A}$, lb. per sq. in.		
	Pin ends	Riveted ends	Average
33,000	13,530	13,780	13,655
55,000	21,330	22,020	21,675

For any given column load, P,

$$A_1 = \frac{P}{13{,}655} \text{ and } A_2 = \frac{P}{21{,}675}$$

Equating values of P:

$$A_2 = \frac{13{,}655}{21{,}675} A_1 = 0.631\ A_1$$

Hence the saving in area is 36.9 per cent, which is the value given by the diagram for the selected conditions of the example.

The individual strength of the component parts of a compression member should not be less than the strength of the member as a whole. Otherwise, premature failure may occur through local buckling. The thickness of material is reduced when high-tensile steels are used, thus creating a greater tendency for buckling unless provision is made against it.

The United States Bureau of Standards made an investigation of the buckling strength of column web plates[3]. The form of test specimen is shown in Figure 4(a). An error occurred in the report on page 753 in the formula for t^2 where Poisson's ratio should have been to the second power. O. E. Hovey prepared a discussion[4] of this report in which he corrected the formula and tables.

From this study the following formula for the ratio of the unsupported width to thickness was derived:

$$\frac{b}{t} = \sqrt{\frac{2.712E}{S_{cr}}} \qquad (4)$$

in which b = unsupported width of plate.
t = thickness of plate.
S_{cr} = critical buckling unit stress.
E = modulus of elasticity.

When we let S_{cr} equal the yield point we obtain the following values of b/t with $E = 29{,}000{,}000$ lb. per sq. in.:

Yield Point, lb. per sq. in.	$\frac{b}{t}$
29000	52.1
30000	51.2
33000	48.8
35000	47.4
40000	44.3
45000	41.8
50000	39.7
55000	37.8

The American Railway Engineering Association Specifications for Steel Railway Bridges have the following requirements for the webs and covers of compression members:

Yield point, lb. per sq. in.	Max. values of $\frac{\text{Width}}{\text{Thickness}}$	
	Webs	Covers
33,000	32	40
45/50000	28	36

Fig. 4(b) illustrates these limiting conditions and it will be seen that these limitations are conservative when compared to the values based upon the tests of the Bureau of Standards.

Table VI—Column Formulae, Pin Ends

Yield point, lb. per sq. in.	Limiting values of $\frac{L}{r}$	Working unit stress, lb. per sq. in.
55,000	0-110	$\frac{P}{A} = 24{,}500 - .880\left(\frac{L}{r}\right)^2$
	110-200	$\frac{P}{A} = \frac{24{,}500}{.52 + \frac{1}{9{,}690}\left(\frac{L}{r}\right)^2}$
50,000	0-115	$\frac{P}{A} = 22{,}200 - .725\left(\frac{L}{r}\right)^2$
	115-200	$\frac{P}{A} = \frac{22{,}200}{.52 + \frac{1}{10{,}660}\left(\frac{L}{r}\right)^2}$
45,000	0-125	$\frac{P}{A} = 20{,}000 - .583\left(\frac{L}{r}\right)^2$
	125-200	$\frac{P}{A} = \frac{20{,}000}{.52 + \frac{1}{11{,}870}\left(\frac{L}{r}\right)^2}$
33,000	0-140	$\frac{P}{A} = 14{,}670 - .316\left(\frac{L}{r}\right)^2$
	140-200	$\frac{P}{A} = \frac{14{,}670}{.52 + \frac{1}{16{,}190}\left(\frac{L}{r}\right)^2}$
29,000	0-145	$\frac{P}{A} = 12{,}900 - .247\left(\frac{L}{r}\right)^2$
	145-200	$\frac{P}{A} = \frac{12{,}900}{.52 + \frac{1}{18{,}220}\left(\frac{L}{r}\right)^2}$

Formulae are based on the "Secant" Formula.
Factor of safety = 1.80.

[3] Reported in Bureau of Standards Technicological Paper No. 327, entitled "Compressive Strength of Column Web Plates and Wide Web Columns."
[4] Bulletin 374 of the American Railway Engineering Association, February, 1935.

(To be concluded next month)

Six Year Summary of Air Conditioned Cars

Table I—By Types of Cars

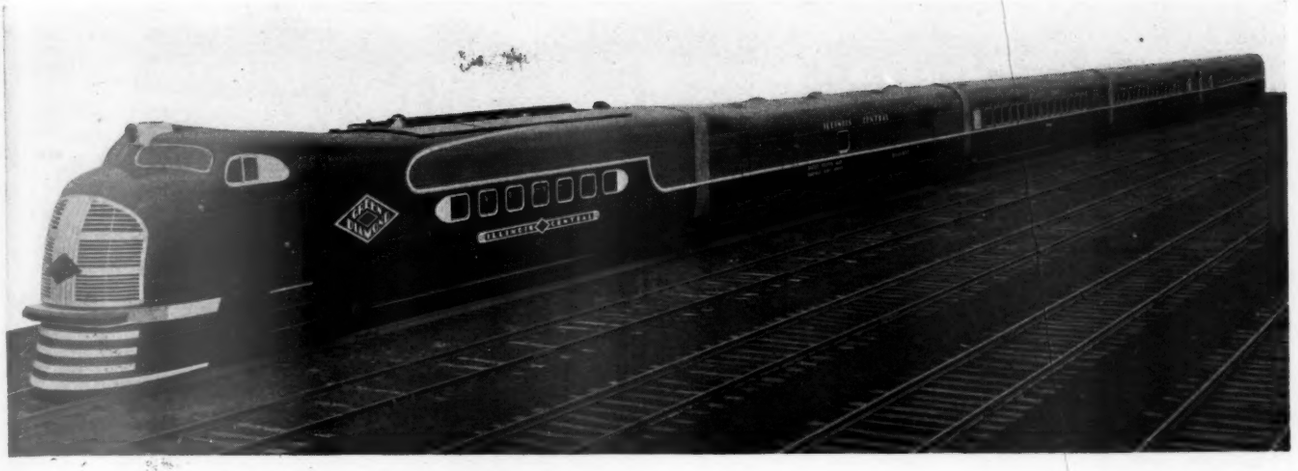
Name of railroad	Total cars: 1933 (Note A)	1934	1935	As of Dec. 31, 1935	Coaches (Note B)	Combination (Note C)	Dining (Note D)	Lounge diners (Note E)	Chair	Observation (Note F)	Sleeping Cars (Note G)	Business
Alton	16	2	7	25	4	4	4	5	6	2	..	..
A. T. & S. F.	23	36	77	136	8	..	41	7	62	18	..	..
A. C. L.	..	7	15	22	15	..	7	..	..	..	..	..
B. & O.	62	59	72	193	93	32	39	15	4	8	..	2
B. & M.	1	10	13	24	18	2	4	..	..	..	..	..
Cen. of Ga.	..	..	4	4	2	..	..	2	..	..	..	..
C. & O.	12	6	19	37	22	..	5	5	..	..	..	5
C. & E. I.	2	4	4	10	2	2	4	2	..	..	..	..
C. M. St. P. & P.	..	22	68	90	38	..	19	7	10	2	14	..
C. B. & Q.	..	25	64	89	25	..	19	7	33	5	..	..
C. & N. W.	5	17	70	92	48	10	15	3	9	7	..	..
C. St. P. M. & O.	..	..	13	13	4	..	5	4	..	..	..	..
C. R. I. & P.	4	17	27	48	..	4	15	10	15	4	..	..
D. & H.	..	..	1	1	..	..	..	1	..	..	..	..
D. L. & W.	..	9	12	21	10	..	6	3	..	1	..	1
D. & R. G. W.	..	12	20	32	16	..	5	4	..	7	..	..
Erie	..	20	1	21	15	..	2	2	..	..	..	2
Fla. E. C.	..	..	11	11	8	..	3	..	..	..	..	..
Ft. W. & D. C.	..	..	14	14	10	..	4	..	..	..	..	..
Grt. Nor.	..	13	16	29	12	..	16	..	..	..	..	1
G. M. & N.	..	..	5	5	1	..	..	2	..	..	2	..
Ill. Cen.	11	..	44	55	2	9	20	14	7	2	..	1
Lehigh Valley	..	2	12	14	4	..	5	2	3	..	..	..
L. & N.	..	8	5	13	..	..	13	..	..	..	..	..
Me. Central	..	7	..	7	5	2	..	..	..	..	..	..
M-K-T	8	4	5	17	..	..	9	..	3	4	..	1
Mo. Pac.	12	26	111	149	58	8	12	38	24	5	..	4
N. C. & St. L.	..	5	..	5	..	..	2	3	..	..	..	..
N. Y. C. System	15	73	58	146	78	..	68	..	..	..	..	..
N. Y. C. & St. L.	..	1	3	4	3	..	..	..	..	..	..	1
N. Y. N. H. & H.	11	56	146	213	167	15	26	..	2	3	..	..
Nor. & West.	..	7	34	41	22	8	11	..	..	..	..	..
Nor. Pacific	..	19	26	45	16	..	15	..	..	14	..	..
Pennsylvania	160	116	93	369	194	72	100	3	..	..	..	..
Pullman Co.	244	1161	1828	3233	..	..	..	..	353	494	2386	..
Reading	..	9	21	30	17	7	6	..	..	..	..	..
C. R. R. of N. J.	..	..	13	13	10	..	3	..	..	..	..	..
R. F. & P.	..	7	10	17	10	2	4	1	..	..	..	..
St. L.-S. F.	17	12	40	69	26	2	11	7	14	5	2	2
Seaboard A. L.	..	26	33	59	23	13	16	6	..	..	..	1
Southern	..	..	27	27	..	..	27	..	..	..	..	..
Sou. Pacific	14	18	106	138	35	..	45	4	39	15	..	..
Tex. & Pac.	7	..	44	51	34	..	9	..	4	3	..	1
Union Pac.	18	38	131	187	63	..	51	..	38	35	..	..
Wabash	6	14	20	40	..	..	..	11	29	..	..	..
Western Pacific	..	4	4	8	4	..	4	..	..	..	..	..
	648	1872	3347	5867	1122	192	670	168	655	634	2404	22

Note A—Includes cars air-conditioned prior to and including 1933.
Note B—Includes coach-club and coach-lounge cars.
Note C—Includes passenger-mail, passenger-baggage and club-baggage cars.
Note D—Includes cafe cars.
Note E—Includes cafe-club, cafe-parlor, cafe-lounge, cafe-coach and buffet-lounge.
Note F—Includes observation-chair, observation-lounge, and club cars.
Note G—Includes sleeper-chair, tourist-sleepers and sleeper-observation cars.

Table II—By Types of Systems and Refrigerants Used

Name of railroad	Total No. of cars	Type of system: Electro-mech.	Direct mech.	Ice	Steam ejector	Refrigerant used: Freon	Water	Ice	Other refrigerants
Alton	25	25	..	..	..	24	..	..	1*
A. T. & S. F.	136	1	..	..	135	..	135	..	1*
A. C. L.	22	3	..	..	19	3	19	..	..
B. & O.	193	193	..	..	..	193	..	..	..
B. & M.	24	13	..	11	..	13	..	11	..
Cen. of Ga.	4	..	..	..	4	..	4	..	..
C. & O.	37	..	37	..	..	37	..	..	..
C. & E. I.	10	..	..	4	6	..	6	4	..
C. M. St. P. & P.	90	..	..	..	90	..	90	..	..
C. B. & Q.	89	51	4	34	..	55	..	34	..
C. & N. W.	92	14	5	73	..	5	..	73	14†
C. St. P. M. & O.	13	..	..	13	..	..	..	13	..
C. R. I. & P.	48	..	..	36	12	..	12	36	..
D. & H.	1	..	..	1	..	..	..	1	..
D. L. & W.	21	..	..	11	..	10	..	11	..
D. & R. G. W.	32	..	10	32	..	..	..	32	..
Erie	21	..	..	..	21	..	21	..	..
Fla. E. C.	11	..	..	..	11	..	11	..	..
Ft. W. & D. C.	14	14	..	..	..	14	..	..	..
Grt. Nor.	29	..	..	29	..	..	..	29	..
G. M. & N.	5	5	..	..	..	5	..	..	..
Ill. Cen.	55	11	34	10	..	45	..	10	..
Lehigh Valley	14	14	..	..	..	14	..	..	..
L. & N.	13	..	..	..	13	..	13	..	..
Me. Central	7	..	..	7	..	..	..	7	..
M-K-T	17	6	..	3	8	3	8	3	3*
Mo. Pac.	149	21	..	97	31	20	31	97	1†
N. C. & St. L.	5	..	..	..	5	..	5	..	..
N. Y. C. System	146	73	58	15	..	131	..	15	..
N. Y. C. & St. L.	4	..	4	..	..	4	..	..	..
N. Y. N. H. & H.	213	132	..	81	..	132	..	81	..
Nor. & Wes.	41	37	..	..	4	37	4	..	..
Nor. Pac.	45	..	45	..	..	45	..	..	..
Pennsylvania	369	66	..	302	1	65	1	302	1†
Pullman Co.	3233	126	1795	1000	312	1921	312	1000	..
Reading	30	30	..	..	..	30	..	..	..
C. R. R. of N. J.	13	13	..	..	..	13	..	..	..
R. F. & P.	17	10	5	..	2	15	2	..	..
St. L.-S. F.	69	..	..	69	..	..	..	69	..
Seaboard A. L.	59	1	58	..	..	59	..	..	..
Southern	27	..	..	..	27	..	27	..	..
Sou. Pac.	138	..	19	111	8	19	8	111	..
Tex. & Pac.	51	1	1	20	29	2	29	20	..
Union Pac.	187	15	144	..	28	159	28	..	..
Wabash	40	1	..	39	..	1	..	39	..
Western Pac.	8	..	..	..	8	..	8	..	..
	5867	876	2219	1998	774	3074	774	1998	21

* Ammonia. † Methyl-chloride.



Illinois Central Receives

The Green Diamond

Five-car articulated train, powered with 1,200-hp. Diesel engine, weighs 476,800 lb., seats 144 persons and cost $425,000.

THE Green Diamond, a five-car, articulated, Diesel-electric train which was delivered recently to the Illinois Central, is now on an extensive exhibition tour of about 50 cities in the Mississippi Valley, the Southwest and the Great Lakes Region. About six weeks will be required to make the 4,000-mile exhibition tour on Illinois Central rails and the 3,500-mile off-line tour which are planned. The exhibition tours will be completed in time to place the train in regular Chicago-St. Louis service on May 17. Sustained speeds well in excess of present schedules will permit this train to make a round trip daily, supplanting two steam trains now required for comparable service.

The new Illinois Central train, designed by the Pullman-Standard Car Manufacturing Company, was built at the Pullman Car Works at a cost of approximately $425,000. It consists of five streamline articulated car bodies embodying, primarily, riveted Cor-Ten steel construction. Aluminum is extensively used for interior finish and decorative features.

The train, with a total seating capacity for 120 passengers, plus 24 seats at dining tables, is air conditioned throughout and provided with modern dining-car facilities. It operates on six roller-bearing trucks, and has a light weight of 476,800 lb., or about 50 per cent of the weight of an equivalent steam train. It is driven by an Electro-Motive 1,200-hp. power plant, with electric generator and motors furnished by the General Electric Company. It is expected that the train will make about 1.5 miles per gal. of fuel oil and 35 miles per gal. of engine lubricating oil. Water consumption for both engine cooling and train heating will depend largely upon outside temperatures, and in a recent test was 700 gal. for a one-way trip of 293 miles.

The overall length of the train is 328 ft. 6 in. and the five body units having general arrangements, dimensions and seating capacities as shown in the drawings, include a power unit, a mail-baggage unit, two chair units and a diner observation unit. Each of the three passenger-carrying bodies has a side entrance door on each side, and the diner-observation unit is provided with an emergency end door.

The exterior of the train is smartly styled. Two shades of green are used for the exterior colors with striping lines of silver and scarlet between the two greens. Lettering of silver aluminum and scarlet is carried out in a modern style. The name of the train, Green Diamond, is worked out in a diamond design with letters of silver and scarlet and applied to both sides of the power unit.

A cast aluminum name plate with the words "Illinois Central" in highly polished letters, separated by a green diamond outlined in silver, is also applied on each side of the power unit, under the windows.

General Construction

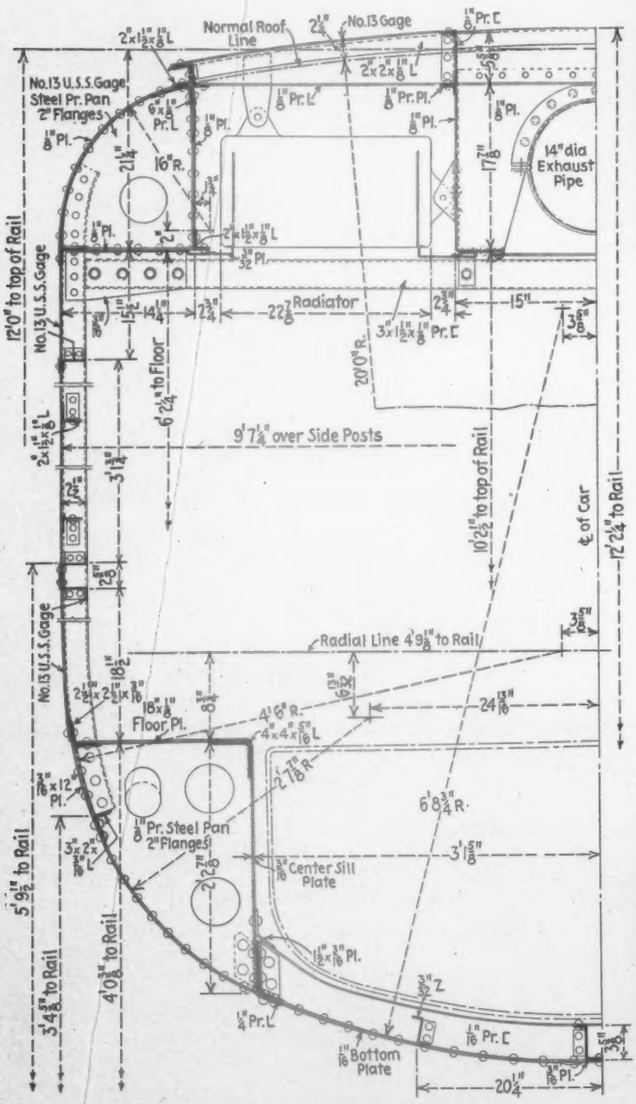
The underframe assembly in each of the Green Dia-

Table lamps supplement indirect lighting in the observation-lounge

mond bodies is a combination of riveting and spot welding. The center sills are of web and cover plates with rolled chord angles. The floor beams are of pressed-steel shapes. The bottom sheet stiffeners and struts between these stiffeners and the floor beams are of drawn or pressed shapes, as are the longitudinal floor stringers.

The bottoms of the car bodies are completely enclosed, brake equipment, reservoirs, tanks, piping, etc., being located in the space between the floor and bottom sheets, accessible through removable floor doors.

The side-sill construction is a combination of drawn

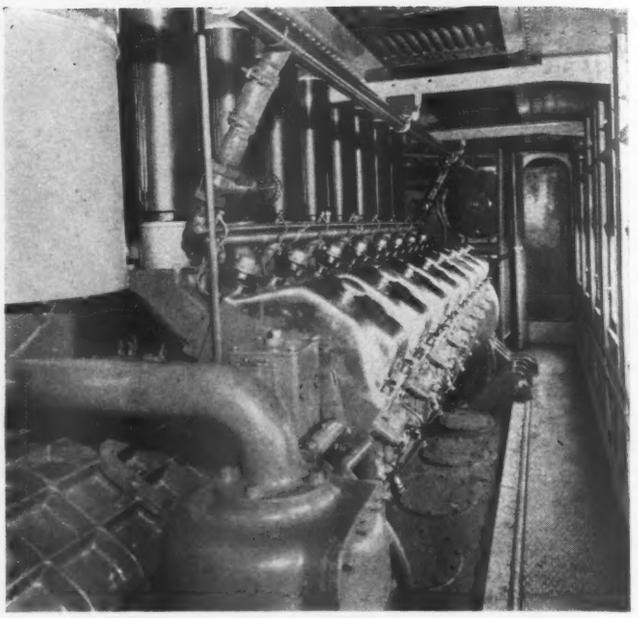


Half section of a passenger-carrying body unit

members and rolled plates, attached to the car bodies by rivets and welding. Side posts are of pressings; where box sections are used, these are formed by welding after these posts were set in place.

Carlines and purlines are of pressed shapes. Roof sheets are riveted. End frames at articulated ends are a combination of riveted and welded construction. End sills are of entirely welded construction, riveted to the framing members. Diagonal braces are used at the ends to tie the shoulder construction to the end sills, connections on end sills being adjacent to the door posts.

While the five articulated Cor-Ten steel body units of this train embody primarily riveted construction, a sub-



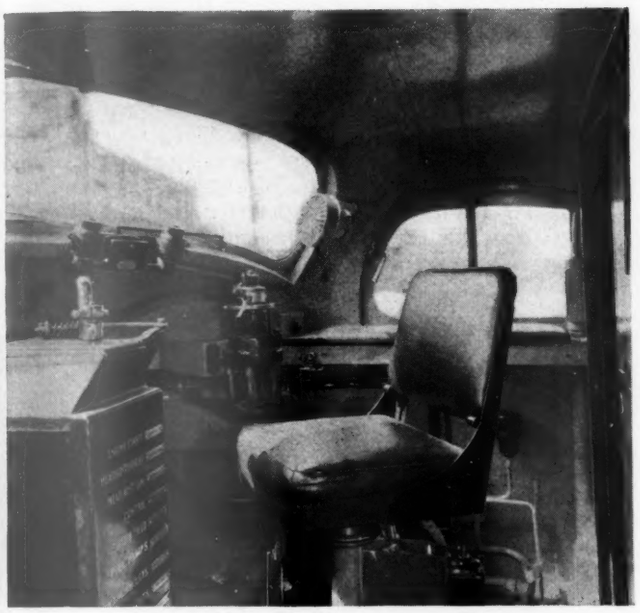
The engine room

stantial amount of electric welding was used in fabricating the underframes and superstructure frames. There is approximately 6,800 lineal feet of arc welding in the train in addition to which about 5,100 spots (machine spot-welds) were used for side-sill reinforcing sub-assemblies.

In the power car approximately 2,200 lineal feet of arc welding was performed on the underframe, front-end assembly, rear-end framing, side and roof framing and removable roof. The body-bolster sub-assembly was built up and welded in jig welds for application to the car.

In the trailing cars some 4,500 lineal feet of arc welding was done. This included many points in the underframe; side and roof framing; end framing and car ends; front ends and rear end framing; post construction and side-plate covers. In addition to these major jobs much miscellaneous arc welding was done on parts such as conduits, door frames, step welds, air-conditioning equip-

The seats have individual reclining backs

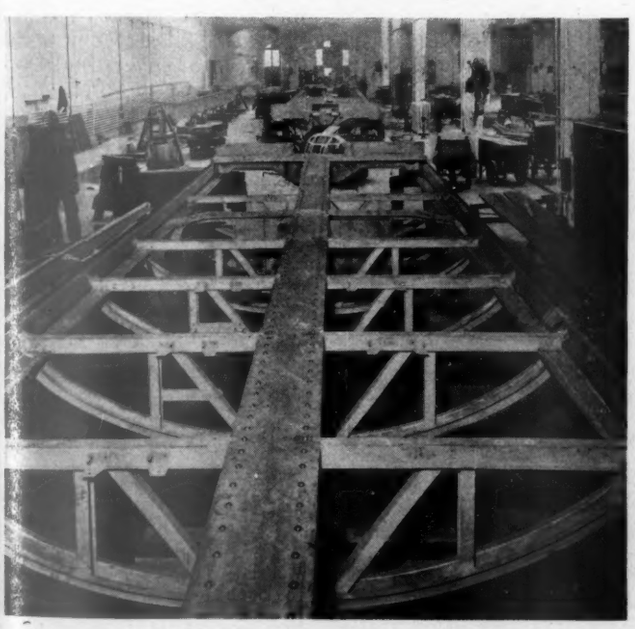


The operator's control station

ment, motor base supports and framing, and fresh air intakes.

The streamline rounded front end of the power car is of built-up angles and plates to form an anti-telescoping construction. The rear end of the train is also of streamline design, provided with observation end sash and emergency door.

The body articulation eliminates the use of couplers, draft gears and the vestibule mechanism, such as commonly used in the conventional types of passenger-carrying cars. The articulated feature also reduces the number of trucks to service and maintain to six instead of ten, as would be required for a similar train of separate cars. The gaps between the units are entirely closed at sides and roofs by means of diaphragms made of extra-stretch pigmented sheet rubber, spanning from one body to the next. The passageways between the bodies are also enclosed and dust tight, inner diaphragms being used. These also are made of extra-stretch rubber. A



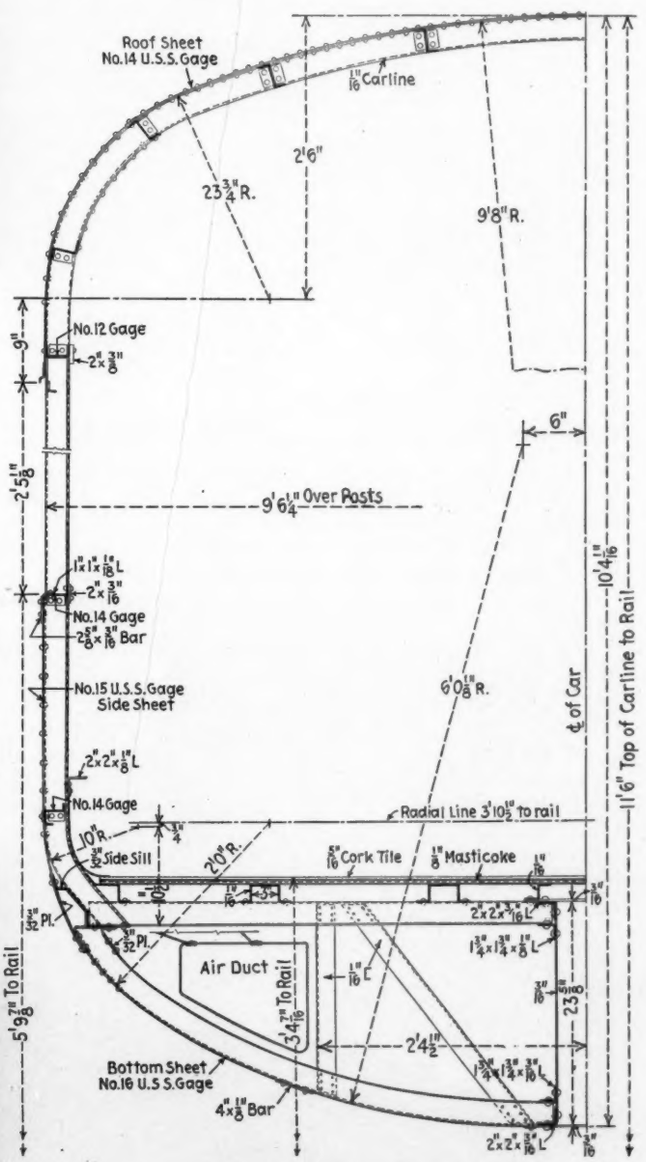
The underframe during construction

drawbar, for emergency use at either the front or the rear end of train is carried on the train.

Interior Decoration

The interior finish and head linings in the passenger cars are of aluminum alloy, the wainscoting being of pressed composition board.

In the passenger compartments horizontal moldings with satin-finish aluminum faces run in unbroken lines from one end of each compartment to the other above and below the windows. The forward ends of each double window are given speed-line curves and further



Half section of the power unit

accentuated by polished aluminum moldings. Three decorative satin-finish aluminum moldings repeating the speed-line curve of the window are used on the frieze panels over each double window.

The two chair cars are handled decoratively as a unit, with blue-grey walls, ivory ceilings and darker blue wainscotings. Floors in the chair compartments are covered with cork tiles finished in natural shades. Carpet of deep raisin tones is used for an aisle strip in the chair compartment.

The unusually comfortable seats are of the three-

position, reclining-type with satin-finish aluminum pedestals and fittings. A two-tone line-pattern of acorn-colored mohair, with the lines running transversely, is used for seat covering.

The window shades are silk-faced with horizontal lines in raisin and acorn colors on a tan background, recalling the color of the carpet and seat covering. The basket racks are enameled to match the ceiling.

Removable card tables and tables for the dining section in the chair cars are of a black formica with inlaid tops and edges of satin-finish aluminum.

The diner-observation car has the same design of finish as used in the chair cars, but is distinctive because of colorings and furnishings. The walls are finished in sea green with ivory ceilings and darker green wainscotings.

The dining section at the forward end of the observation room has aluminum frame chairs in satin finish, upholstered in a gold-colored, horizontal-line pattern mohair. The dining tables are black formica with two inlaid aluminum lines in the top, and with three satin-finish aluminum lines inlaid on the edges.

Lounge chairs are of three types, of a special design, having a special bleached walnut finish on the exposed wood portions. Three types of seat coverings are used; one, a green modern design to tone with the green walls; another of raisin color similar to the carpet; and the last, a key fabric of tan, green and raisin, to tie all the colors together.

Kitchen Equipment and Other Details

The kitchen is provided with an oil-burning range, broiler, warming ovens, urn and steam table. Polished stainless steel is used for table tops, sinks, chipped ice wells, facings of refrigerators, range, work tables and lower lockers. The interior linings of cold boxes, refrigerator compartments, racks, etc., are also of stainless steel.

Dry-ice refrigeration, automatically controlled, is used in the large refrigerators, cold boxes and ice-cream cabinet. The kitchen is provided with a serving bay to facilitate serving meals, which is open on three sides.

All exterior side doors are of steel construction; all end doors and interior doors are of aluminum construction. Passenger side entrance doors are of the hinged type, swinging inwardly. Baggage and mail compartment side doors slide on curved upper guides and lower tracks, designed to bring the doors flush with the sides of the train when closed. Main end doors and toilet-room doors in passenger-carrying bodies are provided with an anti-pinch feature.

Forged steps of designs to suit streamline conditions are provided for the cab and engine compartment, mail room and baggage compartment. The passenger entrance steps are of the pivoted type, operated with sprocket and chain mechanism so designed that the door risers and tread form a part of the platform and door threshold, and the back of the step lines up with the contour of the car shell and entirely closes the step opening when in raised position.

Truck and Power-Plant Details

The trucks throughout the train are of four-wheel type, with Commonwealth frames of cast steel. The trucks supporting the traction motors, that is, the two forward trucks, have wheel bases of 8 ft. 4 in.; the remaining four trucks have 9 ft. wheel bases.

The wheels are of rolled steel, those on the motor trucks are 36 in. in diameter with 1 in. in 20 in. taper treads; the balance of the wheels are 33 in. in diameter with cylindrical treads. Timken outside-type roller bearings are provided on the axles of the two motor trucks. The remaining trucks have American Steel Foundries roller-bearing wheel and axle units with Timken bearings.

All trucks have Simplex clasp brakes and unit truck-mounted air-brake cylinders, one per wheel. Four brake shoes are used in two brake heads for each wheel. Points of contact between brake levers and truck frames are covered with fibre pads to dampen vibration and noise.

Manganese steel liners are used in the bottom of the first motor-truck center plate and between the body and truck center plate on the rear truck. All articulated center plates have manganese steel liners at all wearing surfaces.

All trucks at articulations and the rear truck have a double swing-motion, using auxiliary bolsters and spring planks and providing additional coil springs under the auxiliary bolster for easy riding.

The power-plant equipment in this train was designed and supplied by the Electro-Motive Corporation. The apparatus consists essentially of a two-cycle engine, engine control equipment, engine cooling system, engine exhaust system, engine lubricating system, electric transmission, transmission control apparatus, storage battery and charging equipment, auxiliary oil engine, auxiliary a.c. generator and mechanically driven air compressor.

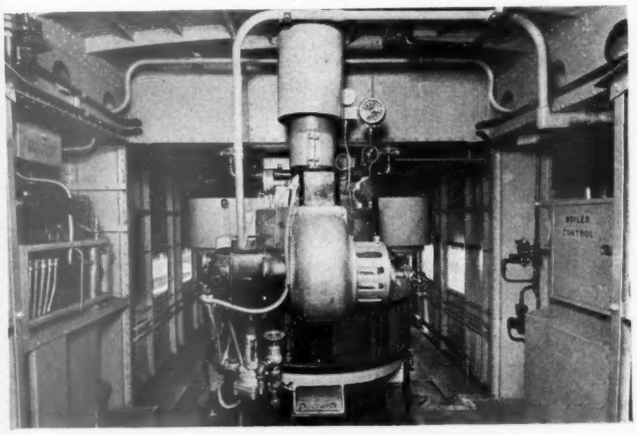
The main engine is a V-type, 16-cylinder, high-com-

The power trucks are equipped with Commonwealth cast-steel frames, Timken roller bearings and Simplex unit-cylinder clasp brakes

pression, two-cycle oil engine of 8-in. bore and 10-in. stroke, developing 1,200 hp. at 750 r.p.m. Power for all auxiliaries driven by the main engine, directly or indirectly, is in excess of its rating.

The cylinder block and crankcase have been combined into one unit of welded steel construction. The engine base of this power plant is of unique design, incorporating in a single welded steel assembly a sub-base for mounting the coupled engine and generator and a fuel supply tank.

The power produced by the prime mover is delivered to the driving wheels through an electrical transmission consisting of General Electric generator, traction motors



High-pressure, oil-fired heating boiler

and PCL control apparatus. This equipment is supplemented by a storage battery and an auxiliary battery-charging generator.

The generator is designed to provide a characteristic most suitable for this particular engine. There are four 300-hp. motors, carried on the first and second trucks.

Weights of Car Bodies and Trucks in Illinois Central High-Speed Train

Light Weights			Light Weights of Body Units	
On No. 1 truck	73,320 lb.		Power	115,800 lb.
On No. 2 truck	65,100 lb.		Mail and baggage	44,100 lb.
On No. 3 truck	46,070 lb.		Chair	52,210 lb.
On No. 4 truck	53,020 lb.		Chair	55,400 lb.
On No. 5 truck	62,290 lb.		Diner-lounge	69,040 lb.
On No. 6 truck	36,750 lb.			
On all trucks	336,550 lb.	336,550 lb.		336,550 lb.
Of No. 1 truck	32,680 lb.			
Of No. 2 truck	33,000 lb.			
Of No. 3 truck	18,790 lb.			
Of No. 4 truck	18,800 lb.			
Of No. 5 truck	18,850 lb.			
Of No. 6 truck	18,130 lb.			
Of all trucks	140,250 lb.	140,250 lb.		140,250 lb.
Light weight of train		476,800 lb.		476,800 lb.

They are of the self-ventilated, heavy-duty railway type. Clean air is supplied to the motors from inside the car body through flexible air ducts supported between the motor and the car underframe.

A 32-cell battery is furnished to supply power for engine starting, transmission control, cab and engine-room lights and emergency train lights. It has a capacity of 450 amp. hr. at the 10-hr. discharge rate.

The power-plant equipment includes a small 110-hp. oil-electric power plant which is provided to supply auxiliary power for the battery-charging and the train-line auxiliaries. This auxiliary unit consists of a four-cycle high-compression oil engine rigidly coupled to a 60-kw., 220-volt, 3-phase, a.c. generator. The driving engine is similar in design to the main engine and develops its rating at 1,200 r.p.m.

Mounted on the auxiliary generator end frame is a 7-kw., 76-volt, d.c. exciter which, in addition to its function of providing excitation for the generator, is used for battery charging. The a.c. power supply will furnish power for the train-line equipment, such as air-conditioning, radio, lighting, kitchen blower, steam-heating control and electric appliances in the kitchen.

The air compressor is a two-stage, water-cooled unit, equipped with inter-cooler between the low- and high-pressure pistons. It is mechanically driven from the main engine and has a displacement of 79.4 cu. ft. per min. at 750 r.p.m.

Heating, Air Conditioning and Brake Equipment

The train is heated by a Vapor, 800-lb.-per-hr., high-pressure, oil-fired steam boiler, burning the same fuel oil as that used in the main Diesel engine. Fin tubing and piping of copper are used in connection with the reduced pressure heating system. The steam train line and other piping under live steam pressure is of steel pipe. Flexible-armored hose connections are used between the body units.

The chair-car bodies and the diner-observation unit also have preheated air admitted through grilled duct openings in the side walls at floor level, this air operating in conjunction with the air-conditioning system.

Both of the chair cars and the diner-observation car are provided with Frigidaire air conditioning equipment.

Brake equipment for the Green Diamond consists of the Type H.S.C. light-weight design with Decelakron electro-pneumatic control, furnished by the New York Air Brake Company. Copper tubing and copper fittings are used throughout except on the trucks and pipes extending outside of the bottoms of body units, which are of heavy steel pipe.

General Lighting System, Signal, Etc.

Indirect lighting from a central duct, forming an architectural part of the cars, is used in the chair cars. There are 200 lights in two troughs, these lights being rated at 15 watts. The lighting circuits operate at 110 volts. Similar indirect lighting, with 185 lights in two center ceiling troughs, is provided in the diner-observation car. Recessed ceiling fixtures of the flush type are used in vestibules, toilets and passageways.

A horizontal headlight and a vertical-beam light are provided, these being in a housing on the roof over the operator's cab. An electric speed indicator is provided, driven from the end of the axle of one of the power trucks, with a dial mounted on the instrument board in the cab. Electric circuit connections between the units is by means of receptacles and jumpers.

Marker lights, consisting of double lights on each side of the car close to the rear end of the train practically flush with the contour of the exterior, are provided. One red lens and one green lens is used on each side of the car, so arranged that each light is controlled independently. This permits a green light to be shown on one side and a red light on the other side at the same time, if so desired. These lights are wired to the battery circuit. Classification lights are provided at the front end of the operator's cab on each side of the car, fitted with white and green lens.

The cab is provided with electric window wipers on each of the two front windows; two circulating fans on adjustable brackets are applied to keep the windshields from steaming up or frosting. The signal system consists of a buzzer in the operator's cab connected to push buttons, one conveniently located adjacent to each side door. Warning devices consist of a horn and a bell. A horn also is located at the rear end of the train for use during backing up operations.

Failures of

Locomotive Parts*

By Fred H. Williams†

Side rods - Failures at the keyway caused by sharp corners and poor machining

LOCOMOTIVE failures are not only costly, but frequently interfere seriously with scheduled train operations. No reasonable expense should be spared to reduce them to a minimum. While a certain percentage of failures is, of course, due to poor material, a surprisingly large number are caused by improper machining and finishing. The railways can afford to go to considerable lengths in the way of research to determine the causes of the failures and to institute proper measures for their elimination.

This article, and others which will follow, are based upon a thorough examination and study of locomotive failures over a period of many years.

The great dragon that appears most frequently is that old fellow "fatigue crack." It appears under various conditions and in most cases is preventable if proper precautions are taken concerning details which may appear to be quite insignificant. Poorly formed keyways, for instance, cause much more trouble than most railroad men realize. This is particularly true in the case of locomotive side rods. The location of the keyway in the forked end of a side rod is usually such that it does not appear to be a source of weakness; yet a careful study of side rod failures indicates that it is a prolific source of trouble.

The illustrations which accompany this article show clearly the type of cracks which start in keyways. A side view of a side rod with a fatigue crack starting from the corner of a keyway is shown in Fig. 1. The two faces of the break indicated in Fig. 1, are illustrated in Fig. 2. The crack started from the keyway and progressed slowly at first, and then more rapidly, as indicated by the width of the waves of the progressive crack, which is what is known as a fatigue crack. Due to the fact that the faces rubbed together and polished each other when the crack was started, the surface is much smoother at the first part of the break. The farther the crack progressed, the coarser the waves and the rougher the surface, until when the failure finally occurred the surface is very coarse.

This is a fatigue crack, although those who are not thoroughly familiar with it frequently report such failures as due to flaws in the metal. Heat cracks or checks are in turn sometimes mistaken for fatigue cracks, although they can readily be distinguished by a critical examination of the broken part. The starting of a fatigue crack is generally very fine and is quite likely to be overlooked.

In Fig. 1, the crack started at the corner of the keyway. It may have been due to a tear in the metal or a sharp cut in the corner that concentrated the stresses in a line. This causes the metal to part, little by little, until the section is so weakened that the strain on the rod is sufficient to cause the break. Only a small part of the rod is shown in the photograph; it is expensive to send cracked and broken rods from distant parts to the test office, and usually a small part, sufficient to show the crack or break, is cut from the rod and shipped in.

Another failure of the same kind, except that it is on one of the forked ends of the side rod, is shown in Fig. 3. The keyway in one side of the fork was cut with square corners; the crack started in one of these and worked its way across the section with the usual characteristics of a progressive, or fatigue crack. The fractured ends of the break in Fig. 3 are shown in Fig. 4. Apparently metal torn out in the corner of the keyway caused the start of the crack. A close examination of the photograph indicates the usual waves which started in the corner and progressed slowly inward. In this instance they are clearer at the start of the crack than at the finish, indicating that the crack opened up at the start and that the final face of the fracture rubbed for some time after parting, thus wiping out the progressive marks which are so clearly shown in Fig. 2.

Another interesting example is shown in Fig. 5. Here we find two cracks, one of which resulted in a fracture. The fractured ends are shown in Fig. 6. The crack, which resulted in the fracture, apparently started first and is known as a primary crack.

Use Fillets in Corners

Obviously the remedy for failures of this sort is to leave fillets in the corners of the keyways and avoid all sharp corners. These fillets should have smooth surfaces and be free from any tears in the metal that may start cracks. Incidentally, the broken sections in Fig. 6 indicate that the fatigue crack started from both sides and at the corners of the keyway.

Another example of a fatigue crack which started in the sharp corner of a keyway and which could have been avoided by the use of a fillet, is shown in Fig. 7. Chalk marks were made on either side of the crack in the attempt to throw it into relief. Another fatigue crack, which started in the corner of the keyway in a forked rod, is shown in Fig. 8.

Fatigue cracks do not always start in the corner of the keyway. This is illustrated in Fig. 9, where the crack is some distance from the corner and was apparently started from a tear, caused by rough milling operations.

Machining Important

It is important, therefore, that the keyways not only be well filleted, but that they be machined with a smooth and fine finish. The use of alloy steels in place of carbon steels does not remove the necessity of filleting the corner of the keyways and having a finish which is smooth and free from tool marks. While the alloy steels are stronger, they are more sensitive and therefore require a smooth finish. It is ridiculous, is it not, for one to make tests of material with the test

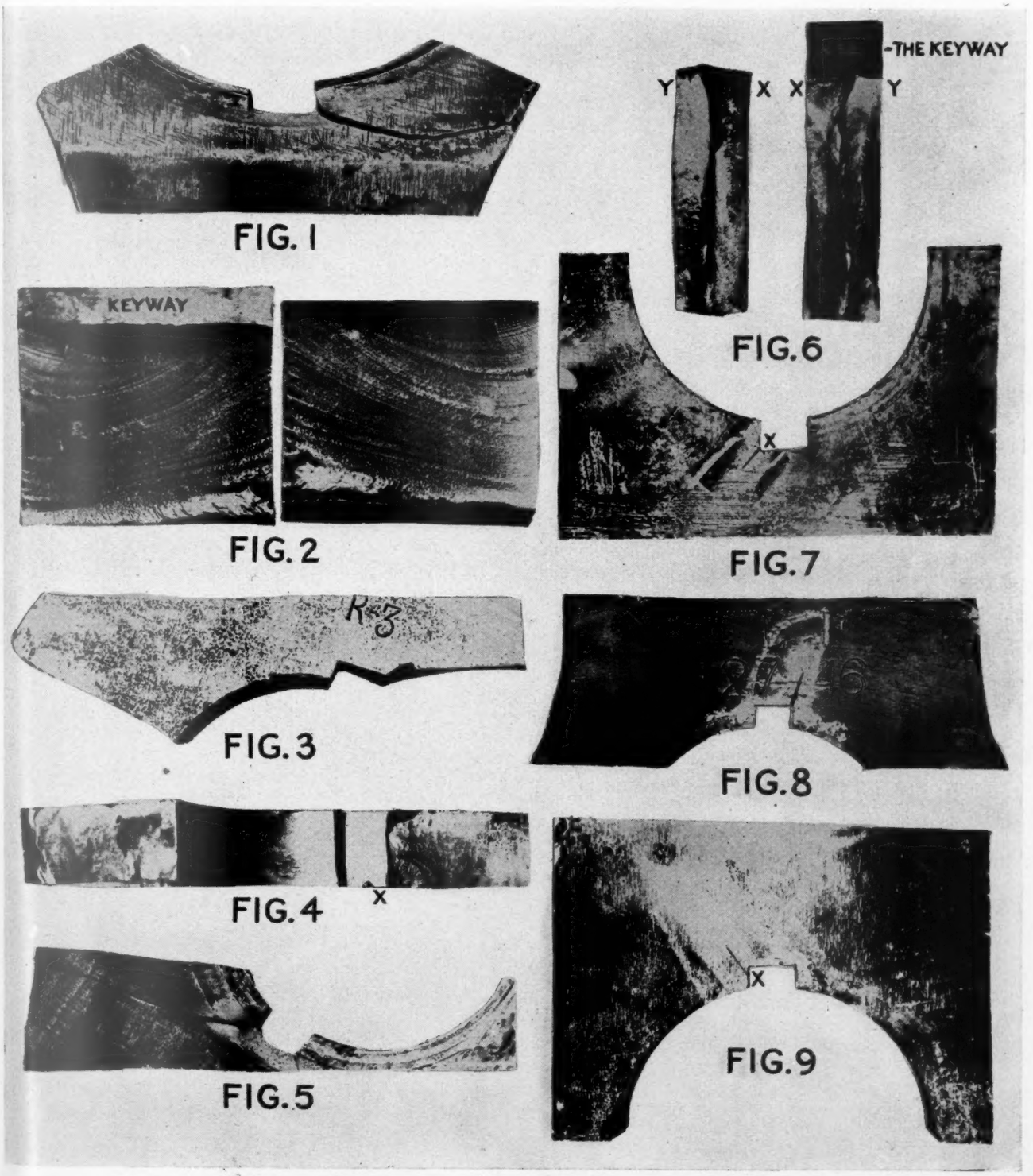
* This is the first part of an article dealing with failures of locomotive parts. The remainder of the article will appear in a subsequent issue.

† Assistant test engineer, Canadian National Railways.

pieces finished with a high polish, and then use a rough finish on the finished product which shows tool marks?

In conclusion it may be said that the type of failure illustrated in this article is not at all uncommon.

In examining some test pieces of a rather intricate design in a plant which maintains the highest possible standards, I was told that the test pieces failed to meet expectations. An examination of the fracture seemed to indicate that the failure was caused by rough



Failures at keyways in side rods

Fig. 1—Side view of a piece of a side rod, showing fatigue crack which started at the corner of the keyway; Fig. 2—The two faces of the break in the side rod, which is shown in Fig. 1; Fig. 3—Side view of fork on side rod, showing fatigue crack which started from the corner of the keyway; Fig. 4—Faces of the break of the side rod, which is shown in Fig. 3. The crack started in the corner of the keyway at X; Fig. 5—A fatigue crack started in each corner of the keyway. The one at the left progressed across the full section, while the one at the right extended only a short distance; Fig. 6—Fractured ends of the side rod shown in Fig. 5. While not clearly shown on the photograph, this fatigue crack started in two places, X and Y; Fig. 7—Another fatigue crack in a side rod, which started in the square corner of the keyway at the left; Fig. 8—A fatigue crack which started in the sharp corner of the keyway; Fig. 9—This fatigue crack started from the side of the keyway, rather than in the corner, and apparently was caused by rough machining.

machining, as indicated by tool marks. I was told that the fracture was a typical torsional one only, since the surface was ground smooth. An examination with a microscope, however, revealed that about one-half inch of the surface, which was hard to get at, was comparatively rough machined; the tool marks could be plainly seen and the crack followed these marks.

A careful check-up of failures would undoubtedly show that many of them are due to poor machining. The use of a little fillet, together with a better finish, would prevent failures in the keyway and cause the part to function successfully indefinitely. In general, fully 90 per cent of the failures are due to the lack of proper machining and finishing the parts in the first place, and to a lack of proper maintenance in the second place, and only about 10 per cent are caused by poor material.

(*To be continued*)

Frank W. Thomas—Morale Builder

Readers of the *Railway Mechanical Engineer* over the past three decades—and there are not a few of them—recognize the A. T. & S. F. as one of the leaders in modern shop apprenticeship training. Frank W. Thomas, engineer of tests of the Santa Fe when John Purcell transferred him and assigned him to the building up of the new apprentice training system in 1907, recently retired from service. Many tributes were paid to him by a large circle of friends and well wishers. A supervisor on the Santa Fe, noticing an announcement of Mr. Thomas' retirement in the Santa Fe Magazine, was inspired to send up a letter about his own experiences, from which the following is quoted:

"I learned of the apprentice system from a boy who had moved from our town out on the branch to the division point, and decided to try to get one of those jobs. I went before the mechanical superintendent and explained to him that I wanted a job and that about all his district lacked of being perfect was to hire me. And although shaking from head to toe I finally got the idea before him. They were not very particular in those days; in fact, they hired and fired regularly and I was hired as a machinist apprentice.

"I received some instructions regarding various rules and regulations and safety matters and went to the tool room to work at the counter and, incidentally, to learn the names of the multitude of tools and also that switch lights are *not* filled with red oil and green oil mixed in equal parts to give the proper indication on the switch lights.

"A course in school room work went along with the shop work and to make things interesting, the instructor announced that he was sending from time to time a few of the best drawings to Mr. Thomas. This stimulated a lot of rivalry among the apprentices and resulted in a number of very good drawings, which were always acknowledged by Mr. Thomas with suggestions that invariably induced better work.

"The courses of study were revised from time to time with a view of giving the best training possible and to build thoroughly from the ground up, so to speak.

"About 1918 the first apprentice club was organized, with the idea of providing entertainment of the right sort for young men in the formative years. It was my privilege to be elected president of the first club and when we gave a 'blow out' invitations were mailed to all the higher officers of the mechanical department. Among my souvenirs of those days is a letter from Mr. John Purcell, regretting he could not attend on the date set for one of the entertainments.

"In the course of time apprentice activities branched out into athletics and the larger division points soon formed baseball, football and basketball teams. The details of the various sports were worked out locally, but the guiding hand and the power behind the throne was none other than Mr. Thomas. Questions arose from time to time regarding the eligibility of players, etc., on account of the fact that some of the smaller shops were forced to use men other than apprentices to complete a team. When these matters were put up to Mr. Thomas for a ruling, it goes without saying that he promptly handed out a decision that covered the situation from every angle, and some of them would have made Kenesaw Landis and Will Hays look like a couple of amateurs.

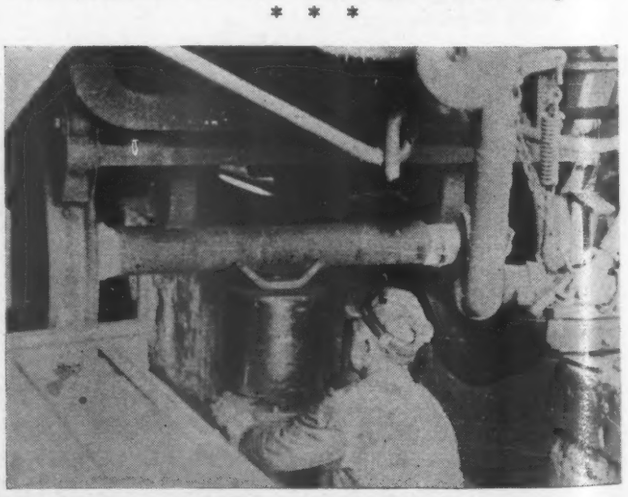
"Mr. Thomas' wonderful personality made many friends and it was always a pleasure to learn via the roundhouse grapevine that he would be in town for the day. He knew all the foremen and instructors by their first names and would go through the shops and roundhouses never overlooking an opportunity to drop a little praise or comment here and there, that seemed to get results without any chafing at the collar anywhere along the line.

"As I look back on the past I feel safe in saying that after one of Mr. Thomas' visits the morale of the place was up 20 points or more. His ability to keep up the morale of the apprentices to a high plane was instrumental in retaining the boys in service until they rounded out their four years apprenticeship, and at the end of that time they usually had acquired enough 'horse sense' to see the benefits of remaining in the service.

"The pep in the apprentice organization made for a good safety record, and it was very seldom that any apprentice suffered a personal injury, and in many cases they led the field in the matter of the fewest personal injuries. A wonderful record when you stop to consider that in most cases the individual was performing the job at hand for the first time, it is a fact that when the morale of the men is up, the accidents are down.

"Mr. Thomas set and maintained a high standard in his work and his reputation for fair dealing and honesty easily distinguished him as a gentleman in every respect. He gave railroading the human touch and the Santa Fe will reap benefits for many years to come from the good work of Frank W. Thomas—Gentleman from Virginia."

* * *



Changing a pair of passenger car truck wheels on a drop pit—A great saving in time is effected in comparison with jacking up a car body and pulling out the trucks to change the wheels

Railroad Diesel Engineering*

By A. H. Candee†

In general construction the gasoline and Diesel engines are nearly identical. The former, however, draws in its fuel in the form of a gas, the gasoline being vaporized and mixed with the proper quantity of air. This fuel mixture is then compressed and fired by an electric spark. The Diesel engine draws in nothing but pure air, and, after this pure air is compressed, the fuel is sprayed into the cylinders in a very fine vapor and fired by the heat generated by compressing the air. This method of introducing the fuel is the fundamental difference between the two engines and is responsible for the much higher thermal efficiency of the Diesel engine. In the gasoline engine, the maximum compression of the gas fuel mixture must be low enough to guard against pre-ignition of the charge due to heat of compression. In the Diesel, the compression pressures may be much higher because only air is involved. The higher temperatures and pressures in the latter case result in greater efficiencies. This also means that the engine parts must be slightly heavier to withstand the higher pressures.

The Diesel engine "grew up" as a marine engine—slow speed for direct connection to propellers and weight of minor importance. Few Diesel manufacturers could foresee sufficient field for the high-speed light-weight Diesel engine to warrant the high expense of development. The application of such engines to rail propulsion, however, necessitated small dimensions and light weight and, with growing demand, such engines have been developed. The Westinghouse engine, the first commercial rail-car engine, weighed around 30 lb. per hp., which compared very favorably with contemporary gasoline engines of similar size, and was a long step forward. This development has been a contributing factor toward the adoption of Diesel engines for rail propulsion purposes.

Within the last four years, the Diesel engine has been given serious consideration by the railroads. It has proved its effectiveness as a source of motive power and has demonstrated that it will actually reduce operating expenses both in rail-car work and in switching work. The trend of the times has also been conducive to its adoption, especially in rail-car work. A period of industrial stagnation always brings out radical ideas of all kinds, both politically and mechanically. New steels have been perfected; new methods of fabrication have been developed. New ideas of all kinds are rampant. The growth of air passenger traffic, even during the depression, has focused the attention of the public on aerodynamic construction and has had its effect on railroad train construction. The public preference for fast service, as evidenced by the air traffic growth and the stepping up of automobile speeds (40 miles per hour was fast road driving in 1925) has led some of the railroads to the conclusion that the provision of fast train service would be welcome, especially from Chicago to the western cities. Consideration of such fast trains led to the adoption of light-weight construction, streamlining, articulation and the Diesel engine, since these features bring the power requirements down within the range of present engine construction.

The development of the modern streamlined passenger train may be definitely traced to rubber tires. The Michelin tire, as brought out in France for rail purposes and later tried in this country, necessitated light-weight car construction. To construct such light-weight cars, a new method of steel fabrication was developed in this country. With the increase in car weights and the consequent abandoning of rubber tires, the new fabrication methods were retained. This experience in light-weight construction and reduced cross sections of cars pointed the way for further combination of such construction and aerodynamic lines, which puts the power requirements, even for high speeds, within the range of Diesel engine capacities. Thus, the so-called high-speed streamlined trains which have been operated or are on order, are

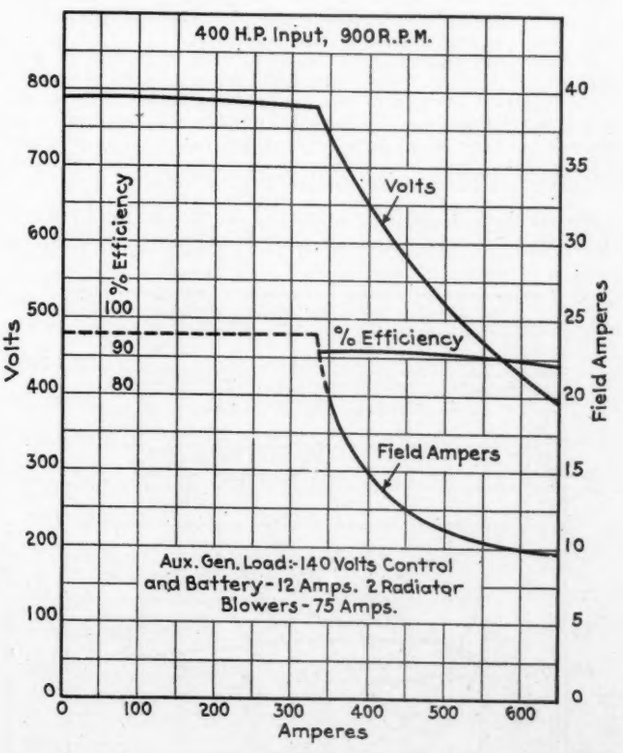


Fig. 1

Diesel-engine driven. As a matter of fact, increases in speeds of railroad trains are not as much a function of light weight construction and streamlining as of grades, curves and traffic hazards. The only difference between a light-weight streamlined train and a conventional train is in the amount of power required for propulsion, and the present steam motive power is adequate to pull any normal train at as high a speed as these limitations will allow.

* This is the first part of a paper presented at the Massachusetts Institute of Technology, March 16, 1936, dealing with the engineering considerations involved in the application of Diesel railroad motive power to rail transportation problems. The remainder of the paper will appear in a subsequent issue.

† Diesel-electric engineer, Westinghouse Electric & Manufacturing Company.

The transmission of power from a prime mover to the wheels of a locomotive or rail car has been the subject of a great amount of thought. Mechanical transmission from reciprocating steam engines is simple, and has been proven to be practical and reliable. Transmission of power from internal-combustion engines, however, is not as simple, since the prime mover cannot develop torque at zero speed. Among the systems proposed and tried are: mechanical drive (clutches, change gears, universal joints, etc.); hydraulic transmissions; pneumatic drive, and the electric transmission.

The apparent simplicity of the mechanical system gave it an advantage during the early stages of self-propelled rail car and locomotive development. With the gradual increase in engine sizes and train weights, every opportunity was afforded to develop such transmissions, and, as an actual fact, they were used with some success up to 175 hp. engine sizes. In spite of the intensive development, such transmissions have not persisted in the larger engine capacities, and nothing spectacular has appeared to date to show a reasonable expectancy of results better than have already been found.

Mechanical transmission involves a number of problems which have not, as yet, been successfully solved for large horsepowers (above 150 hp.) and which are troublesome in even lower horsepowers:

1—Transmission from a spring-borne body to a swivel truck.
2—Transmission to an axle, one end of which may move up or down (with rail joint depression, etc.), and which has some lateral movement in the truck, as well as longitudinal movement in the journal-box guides.
3—Engine mounting on the truck to reduce the problems of (1), result in high engine maintenance.
4—Gear-shift transmission results in poor utilization of available engine power. Thus, each time the gear ratio is changed, power must be completely removed and engine speed dropped to approximately half speed (and half horsepower), following which the engine must accelerate the load to regain full horsepower. This is often impractical with varying railroad grades and results in long operation in an uneconomical gear ratio.

In spite of numerous attempts to use it, no hydraulic transmission has yet been found adequate for railroad service. The main difficulties are due to low efficiency, high maintenance, oil leakage and emulsification of the oil.

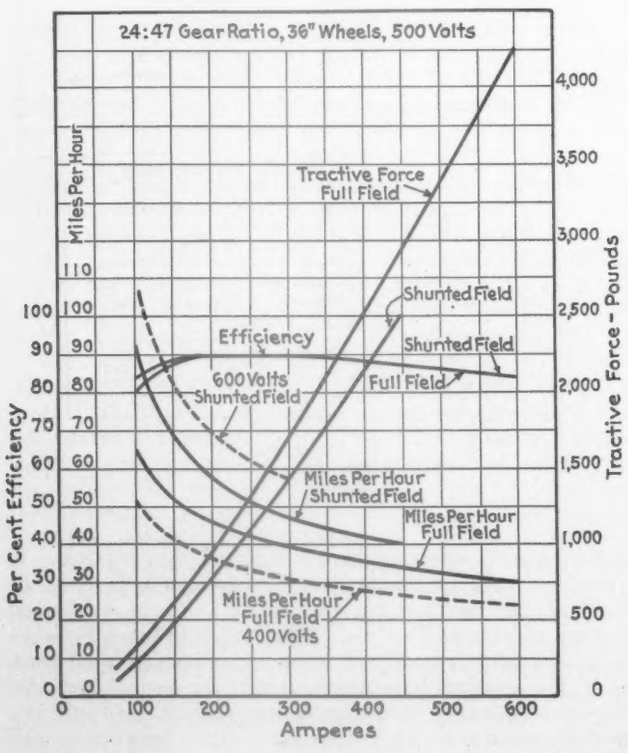


Fig. 2

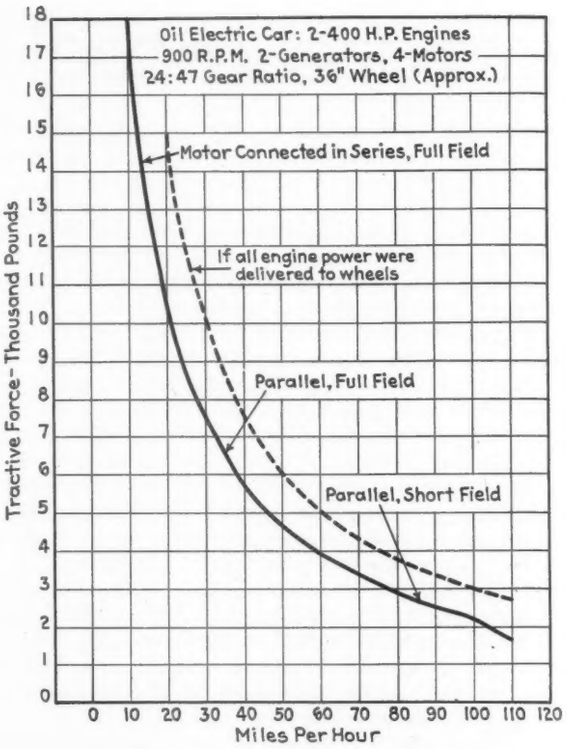


Fig. 3

There have been numerous attempts to employ compressed air for power transmission purposes. The fact that these attempts have resulted in no extended use of this system speaks for itself. Other freak drives (such as combinations of steam and Diesel drives) have not as yet attained a commercial status.

The only satisfactory system of power transmission for internal-combustion rail motive power is the electric system. The reasons for this are:

1—Low maintenance costs as compared to other transmissions.
2—Less physical labor for enginemen in control.
3—Greater overall efficiency and engine power utilization.
4—Maximum tractive force and maximum speeds not a function of the engine.
5—Simple to apply power to multiplicity of driving axles.
6—Operation of auxiliary apparatus is simple.
7—Double-end or multiple-unit control is simple.
8—Power plant may be located in the most advantageous position.
9—Every engine has one or more critical speeds. These may be avoided by electrical transmission.
10—Experience has proved the economy and reliability of this system.

Essentials of Electrical Transmission Systems

The essential elements of an electric transmission system are a generator driven by the engine, traction motors for driving the vehicle, and a control system for connecting the traction motors to the generator, reversing the direction of movement, and regulating the power output of the generator. The main generator is usually built with an auxiliary machine or exciter mounted on the same shaft to generate electrical energy for excitation and for auxiliary purposes.

For simplicity of control, nearly all electrical transmission systems generate and use direct current at voltages (depending upon individual designs) from 600 to 1,000 volts maximum, although the voltage may be selected to give the most economical design. Since the

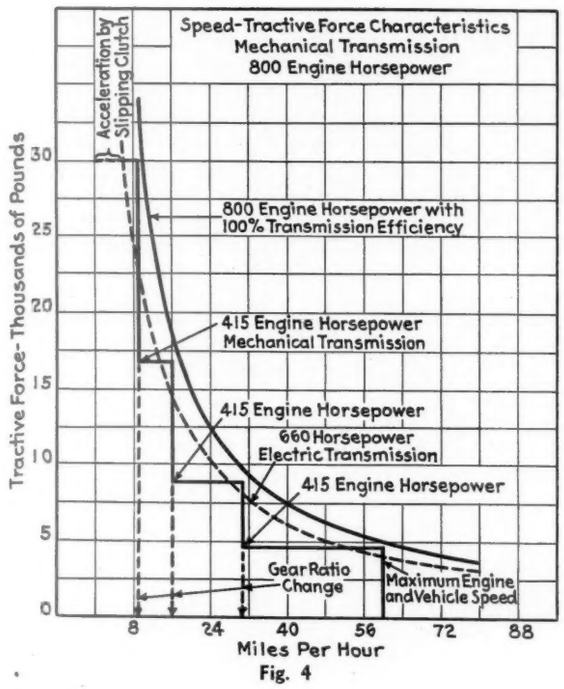


Fig. 4

power of the engine is constant and the tractive force (current) requirements of the traction motors are exceedingly variable, the generator voltage must also be variable over a wide range. This is shown by Fig. 1, which is the characteristic of each generator of the New Haven's train, the "Comet." The Diesel-electric generator is normally a separately excited commutating pole machine, the armature being wound with Class B insulation. A differential series field is sometimes provided for regulating the load to match the engine capacity, but due to the size increase of the generator when this differential field is included, most designers prefer to have the load-regulating means external to the main generator. Another series field is provided in these machines to permit the main generator to act as a series motor for starting the engine, receiving its power from a storage battery.

The mechanical connection of the generator to the engine may be made in several ways. The frame of the machine may be bolted directly to the engine crankcase or may be mounted on a common bed with the engine. The latter method appears to have some advantages over the former. Some of the early generators were of the two-bearing type, but it is now common practice to build single bearing machines with the armature supported at one end by the engine crankshaft. The coupling between the engine crankshaft and the generator armature may be rigid or have alignment flexibility, but rotational flexibility is apt to be dangerous because the resonant effects induced by the engine pulsating torque may set up severe stresses in the shafting.

The traction motors used for Diesel motive power are of the series type, but differ to some extent from those used for electric trolley systems, in that the ratio of core losses and copper losses may be readjusted, because, with Diesel motive power, high currents and high voltages may not occur simultaneously within the power of the engine. This means that core losses higher than would be considered acceptable for trolley systems may be tolerated if the resultant design permits a reduction of copper loss. This theory of design has resulted in motors having a high weight efficiency. As far as mechanical design is affected, the chief difference between the motors for Diesel equipment and for trolley systems is that axle bearing sizes have been increased for the Diesel applications because the additional weight of power equipment necessitates the use of larger axles. Fig. 2 is the characteristic curve of each of the traction motors as used on the "Comet." While this motor is rated at 500 volts nominally, it may be noted that the generator develops nearly 800 volts and the motors operate at this voltage. Fig. 2 shows the effect of 400, 500 and 600 volts impressed across the motor, also the resultant increase in speed by shunting of the motor field.

The actual performance of the equipment with a generator having a characteristic as shown by Fig. 1 and two motors having characteristics as shown by Fig. 2 is shown by Fig. 3, this curve being plotted in terms of speed and tractive force. This same general shape of curve is characteristic of all Diesel-electric equipments, where the power of the engine limits the performance. It may be noted that since horsepower is the product of miles per hour and tractive force divided by 375, the full horsepower of the engine, if plotted, would be a true hyperbola. The deviation of the performance shown by Fig. 3 from that true hyperbola is due to variable efficiency of the electrical equipment with varying speed and current conditions. Another interesting point in connection with this curve, as compared with a performance curve of motors operating from a constant potential trolley system, is that changes in gear ratio or in wheel diameter can change this performance but slightly over that portion of the curve below the full generator voltage, such changes only resulting from slight alterations in the efficiency of transmission. It may be noted that this curve is formed of four distinct parts, the first showing the motors to be connected in series across the generator, the second with motors in parallel, the third with the motors in parallel and their fields shunted, and the fourth portion is the same as the third except that the motors operate at constant voltage.

It is customary to connect the traction motors in series during the early stages of an acceleration. By this expedient, the current drawn from the generator is half of that required if the motors were connected in parallel, and thereby the losses in the generator are reduced. This

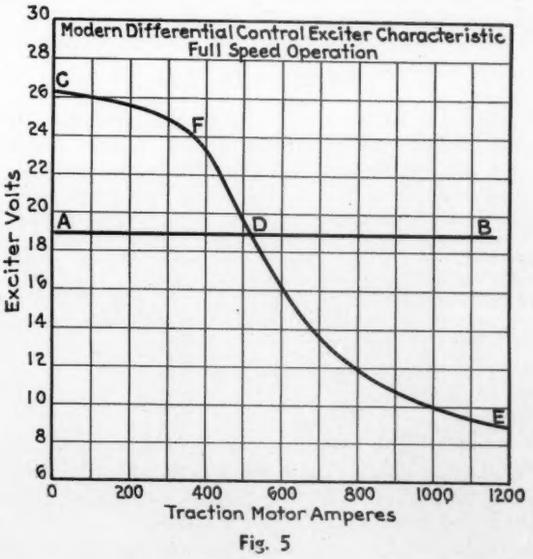


Fig. 5

improves the equipment performance materially over the heavy tractive force range of an acceleration.

Following an acceleration through from a start to full-speed running, the motors are first connected in series relation across the generator with the engine idling, after

which the engine speed is gradually raised at a rate sufficient to maintain the desired accelerating tractive force until full engine speed is attained. From this point, all further increases in train speed are accomplished by electrical changes. As the train continues to speed up (and consequently the motor current decreases), the generator field is increased to raise the voltage gradually so as to keep the engine fully loaded until full generator voltage is reached. At this point, the traction motors are connected in parallel relation and the generator voltage is decreased to half voltage, again being raised gradually to full value. The next operation is to weaken the traction motor field, which may be accomplished by connecting a non-inductive shunt across them, thereby increasing the current demand, which requires another drop and gradual increase in voltage. With full voltage attained under these conditions, the motors operate at constant voltage for any further speed increase.

Mechanical and Electrical Transmission Comparison

It may be of interest to compare the performance of a mechanical system of transmission, driving through gears, with that of an electrical system. In order to provide for variable ratio of engine torque to propulsion torque, it becomes necessary to build the gear drive with gear-ratio changes, and for mechanical reasons it is desirable to limit the number of such shifts to a minimum. This results in poor utilization of the available engine power. Reference to Fig. 4 indicates that each time the gear ratio is changed, power must be completely removed and the engine dropped in speed (and horsepower), following which the engine must accelerate the complete train in order to regain full engine speed and horsepower. This is often impractical with varying railroad grades and may result in long operation in an uneconomical gear ratio. Comparing this with an electrical system of transmission (as shown by the dotted curve), it may be seen that the latter system corresponds to a geared system having an infinite number of ratios, and, although the efficiency of the drive may not be as high as that of the mechanical system, the general utilization of engine power throughout the range of train speeds is much better. The electrical system adapts itself exactly to the loads and to the grade conditions of the railroad.

Auxiliary Details

Among the items which form any complete Diesel-electric motive-power equipment for a car or locomotive are such auxiliary equipment as:

1—Radiator cooling fans and drive.
2—Air-brake compressors.
3—A storage battery for engine starting, emergency lighting, and control.
4—An auxiliary generator for the supply of auxiliary power, field excitation, and battery charging.
5—A system of control for proper engine loading and for control of auxiliary functions.

Other auxiliaries are sometimes provided for special purposes, such as a train steam-heating plant and air-conditioning equipment.

In most of the modern Diesel motive-power equipments the radiator fans are electrically driven. The motors operate at relatively constant voltage from the auxiliary generator whether the Diesel engine is idling or delivering traction power, except that they may be disconnected automatically or manually if the water or lubricating-oil temperatures fall too low for the best conditions of engine operation.

The air compressors used for electric locomotives or cars are normally air cooled. For Diesel motive power, however, where a water cooling system is available, water cooled compressors may be employed and may be mounted in a more convenient location because ventilation is not necessary. Single-stage water-cooled compressors may be used for the higher-pressure and higher-capacity braking systems which would require two-stage compressors if air cooled.

The capacity and voltage of the storage battery is generally determined by the starting requirements of the engine, although there are some cases where air-conditioning requirements have determined this size. In starting an engine the torque required to turn the engine initially with cold bearing surfaces determines the maximum current capacity, and the firing speed of the engine fixes the minimum battery voltage. An 800-hp., 12-cylinder Diesel engine requires a 54-cell lead battery of 235 amp. hr. capacity.

The auxiliary generator or exciter is usually driven by the main engine, the frame being mounted on the bearing housing of the main generator and the armature being pressed onto an extension of the main-generator armature shaft. This construction eliminates the necessity of bearings for this machine. In some installations this auxiliary generator has been driven by a separate engine. The voltage of this machine is determined by the maximum voltage required for battery charging and its capacity by the auxiliary load connected to it.

The air-brake systems used on Diesel motive power are fundamentally the same as are used on electric locomotives and cars. Some modifications and refinements have been incorporated in brake equipment for high-speed trains because of the wide range of speed through which such trains operate.

Control Systems for Electrical Transmissions

One of the most important design features in the production of Diesel electric railway drives is the system of control employed for proper utilization of the engine power. Among the factors which must be considered are:

1—Engine power must be utilized to the fullest extent because the engine capacity which may be applied is necessarily limited.
2—Control must not overload the engine, because this results in smoky exhaust and high engine maintenance.
3—Application of power to the traction motors must be well regulated to prevent rough train operation.
4—An adequate supply of power must be available for the operation of auxiliary equipment and battery charging.

In general, there have been three major systems of control used in the past:

1—Separate manual engine-speed control and manual variation of generator-field strength.
2—Manual variation of engine speed and windings incorporated in the generating equipment for automatic variation of the main-generator voltage.
3—Manual variation of engine speed and external regulating means for varying the main-generator voltage in accordance with the current demands of the traction motors.

It may be noted that each of these systems includes means of varying the engine speed. It has been found advisable to operate the engine at its minimum permissible speed when propulsion power is not required, in order to reduce lubricating-oil consumption, fuel consumption, engine wear, and to minimize noise. Also, since it is not always necessary to operate the engine at full speed in order to obtain the power required to move a train, it has been found expedient to arrange the control system to obtain any intermediate speed between idling and full speed.

Manual Load Regulation

Manual variation of the main generator field to obtain maximum voltage permissible (within the power

of the engine) for the varying traction-motor current demands theoretically gives excellent control of the engine power output, but requires considerable attention on the part of the operator and that he be located adjacent to the engine so that he may tell by the sound of the engine when it is being overloaded. This system, however, was found to have practical objections because the operator's duties required that his attention be on other things. This led to the development of automatic loading-control schemes.

Differential Control

The early control systems of the gasoline-electric rail cars built subsequent to the war were based on the regulation of generator voltages by means of differential field windings. The first of these was a straight differential field (carrying motor current) on the main generator. The main disadvantages of this were the large increase in main generator size for a given output and its poor engine loading characteristics. When it is considered that the volt-ampere curve of a generator for constant engine output must be hyperbolic (concave) in shape and that the regulation by such a differential field is convex in character, it may be readily seen that it is difficult to produce satisfactory engine loading except over a very small range of voltage. An improvement over this was brought out by Westinghouse in 1925, wherein the differential field is placed on two poles only of a six-pole exciter. This means that the increase in size of the rotating machinery made necessary by the use of the differential winding, is confined to a relatively small unit, and the total increase in generating equipment weight and cost is small. The chief feature of this design, however, is a generator output curve which is nearly hyperbolic in shape, resulting from the winding of the differential field on but two poles of the exciter and saturating these poles. Thus, if it is considered that the separate excitation of the exciter is from a battery, it may be readily seen from Fig. 5 that the voltage generated in the exciter armature by the four unsaturated field poles is relatively constant, as shown by line AB. Also, voltage generated by the two saturated poles when no motor current flows, adds to this 4-pole voltage but is limited by the magnetic saturation of the pole pieces. Now, it is obvious that at some definite value of motor current flowing through the differential winding, such as at the point D, the flux through the two poles is zero, and therefore the resultant voltage lies along curve AB and that as the motor current increases, these poles again saturate in the reverse direction. With this design, the portion of the curve from F to E may be made approximately hyperbolic in shape, and since this machine is used for exciting the main generator, this characteristic is reflected in the output of the power plant. This general idea is used in practically all modern differential control systems.

(*To be continued*)

Illinois Central

1,800-Hp. Diesel Locomotive

THE Illinois Central placed in service in March an 1,800-hp. Diesel-electric locomotive built for freight transfer service. The main power plants consist of two 900-hp. Ingersoll-Rand Diesel engines with General-Electric electrical equipment including generators, traction motors and controls. The total weight of the locomotive is 342,000 lb.

The power plants are mounted on a welded, fabricated-steel underframe the principal members of which consist of four H-beam sections 24¼ in. deep, weighing 120 lb. per ft. The cab is of steel, welded, with radiators at each end for cooling the circulating water and oil from the engine.

The entire locomotive is carried on two six-wheel

Illinois Central 171-ton, 1,800-hp. Diesel-electric locomotive

End view of the locomotive showing the cab and truck arrangement

power trucks having Commonwealth cast steel frames. An interesting feature of these trucks is the fact that the draft gear is attached directly to the trucks. By this design pulling stresses are carried through the underframe for only one truck.

The Diesel Engines

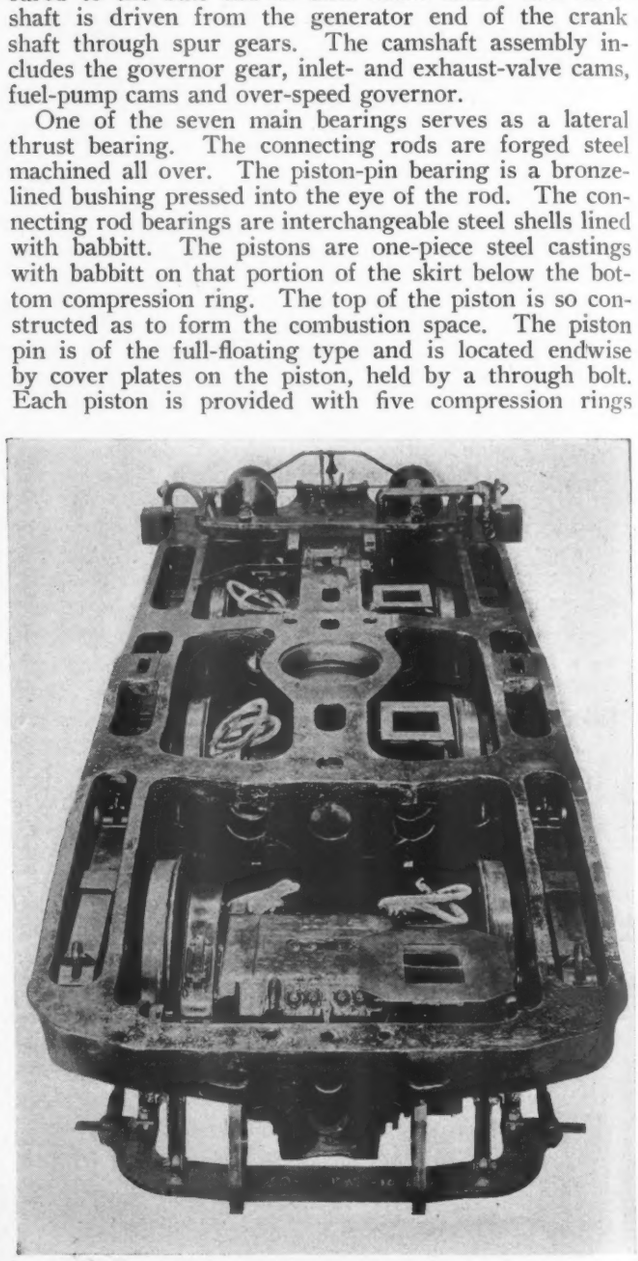
The Ingersoll-Rand Diesel engines are of the six-cylinder vertical trunk-piston, single-acting type operating on the four-stroke cycle with direct fuel injection. The bore and stroke are 14¾ in. by 16 in. They have a rated output of 900 brake hp. at 550 r.p.m. The engine subbase is of welded steel construction and extends the full length of the engine housing forming the oil sump and support for the entire engine. The engine housing is a steel casting bolted to the sub-base and forms the main support for the crankshaft, camshaft and cylinders.

Each of the six cylinders is a separate casting with integral water jackets, which are provided with eight hand-holes for cleaning. Cooling water enters the cylinder jackets at a point about two-thirds the distance from the bottom of the jacket to the top of the cylinder.

The cylinder heads are constructed so as to incorporate the inlet and exhaust manifolds. The adjoining sides of the heads are flanged and are bolted together with a metal-to-metal joint. One injection spray nozzle is held by clamps in each side of the head. The cylinder heads each contain one inlet and one exhaust valve which are actuated by push rods and rocker arms mounted on the heads. The valve actuating mechanism is completely enclosed and is lubricated by oil under pressure. The inlet valves are of low-carbon steel and the exhaust valves are of silchrome steel. Each valve has two coil springs.

The crankshaft is a one-piece steel forging having six cranks and seven main bearings. The crank pins are hollow and the crank shaft counterweights are secured to the butt end of each crank arm. The camshaft is driven from the generator end of the crank shaft through spur gears. The camshaft assembly includes the governor gear, inlet- and exhaust-valve cams, fuel-pump cams and over-speed governor.

One of the seven main bearings serves as a lateral thrust bearing. The connecting rods are forged steel machined all over. The piston-pin bearing is a bronze-lined bushing pressed into the eye of the rod. The connecting rod bearings are interchangeable steel shells lined with babbitt. The pistons are one-piece steel castings with babbitt on that portion of the skirt below the bottom compression ring. The top of the piston is so constructed as to form the combustion space. The piston pin is of the full-floating type and is located endwise by cover plates on the piston, held by a through bolt. Each piston is provided with five compression rings



Top view of the six-wheel truck showing the traction motors, spring arrangement and brake equipment

above the pin and two ventilated oil-drain rings below.

The engines are equipped with six Bosch fuel-injection pumps which deliver properly timed and measured quantities of fuel to the cylinders. The fuel injection pumps receive fuel at low pressure from a header extending along the engine. Each pump delivers fuel at high pressure to the two spray nozzles of the cylinder which it supplies. The spray nozzles, each having a single orifice, are located on opposite sides of the cylinder head and direct the fuel into the combustion space.

The speed of the locomotive is controlled from the operator's position at either end of the locomotive by a manually operated throttle, which is mechanically connected to the oil-engine governor. A Woodward governor, driven by bevel gears from the camshaft, con-

trols the engine speed through a mechanical connection to the fuel injection-pump control shaft.

The connection between the engine and generator is a flexible coupling of the laminated-disc type which takes care of any angular misalignment between the engine and generator. The weight of the armature is divided between the flexible coupling and the generator bearing.

All moving parts of the engine are lubricated by a pressure-feed system supplemented by splash and sprays from the pressure-lubricated parts. The lubricating-oil supply is stored in the sump of the engine sub-base. Oil pressure is regulated by a spring-loaded relief valve in the oil piping between the engine and the cooling radiators. A lubricating-oil safety switch, wired into the electrical control circuit is provided to stop the engine in case of loss of oil pressure.

The engine cooling water is circulated by a centrifugal pump located at the front end of the engine which delivers cooling water to the cylinder heads, and thence to the radiators. From the radiators the water is piped back to the circulating pump.

The engine is started electrically by motoring the generator from energy supplied by the storage battery. While this is being done compression in the engine cylinder is released by a mechanism which holds the exhaust valves off their seats.

A centrifugal-type over-speed governor is driven from the camshaft and operates on a safety switch wired into the electrical control circuit.

General Characteristics

Total weight	342,000 lb.
Weight, per axle	57,000 lb.
Tractive force, continuous at 13.8 m.p.h.	38,800 lb.
Tractive force, one hour, speed 12 m.p.h.	44,400 lb.
Tractive force, 30 per cent adhesion, speed 3.7 m.p.h.	102,600 lb.
Maximum speed	60 m.p.h.
Length, between coupler knuckles	60 ft. 0 in.
Total wheel base	48 ft. 0 in.
Truck centers	37 ft. 4 in.
Rigid wheel base	11 ft. 0 in.
Truck wheel centers	5 ft. 6 in.
Wheel diameter	39 in.
Width over cab side sheets	10 ft. 0 in.
Heights from rail:	
Overall	15 ft. 2 in.
Cab floor	5 ft. 10½ in.
Capacity of fuel oil reservoir	1,150 gal.
Capacity of lubricating oil reservoirs, (one engine)	200 gal.

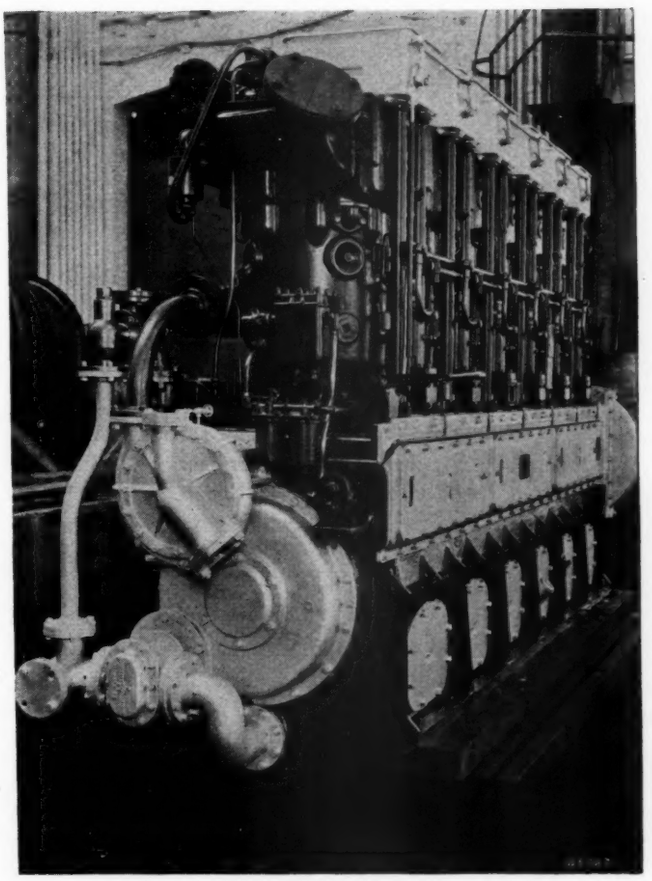
The over-speed safety switch contacts are connected in series with the lubricating-oil safety switch and a shutdown solenoid, which is mounted on the governor housing. When all of the contacts are closed and the electrical circuit is complete, the solenoid is energized and allows the fuel-injection pumps to be under governor control. Opening any of these contacts, or failure of the circuit will stop the engine.

Electrical Transmission

The two engines are placed side by side in the central portion of the cab and a traction-type direct-current generator is directly coupled to each of the engines, with a 125-volt constant-voltage auxiliary generator carried on an extension of the main generator shaft. Mounted on top of the auxiliary generator and belted to the main shaft is an exciter set which is used exclusively for supplying variable current to the main-generator fields. A flexible coupling is used between the engine and the main generator.

The traction motors are type GE-716, with a maximum gear reduction of 62 to 15. The design permits a maximum locomotive speed of 60 m.p.h., calling for a motor speed of 2,140 r.p.m. The motors are of the usual single-geared traction-type, the one side carried on the axle and the other supported by a flexible nose suspension on the truck transom.

Double-end General Electric Type P control equipment is provided, arranged for single-unit operation.



One of the Ingersoll-Rand 900-hp. engines

Should one of the engines be shut down, it is still possible to obtain maximum tractive force and thus to handle the usual weight of train, but at reduced speed, by cutting out the unused generator.

Auxiliary Equipment

The auxiliary generator providing 125 volts at all engine speeds, from idling to full speed, supplies power for the radiator-fan motors, traction-motor blower sets, air-brake compressors, lighting circuits, cab-heater motors, battery charging and excitation for the exciter.

The equipment in the main cab, in addition to the generating sets, includes two traction-motor blower sets, one for each truck, and two air compressors. The ventilating air is carried through a duct above the truck, which has a sliding connection above the air inlet to each motor. Underneath the cab is a 1,150-gal. fuel tank, the storage battery and the air reservoirs.

At each of the operating positions there is a throttle, master controller, gages, instruments, switch panels for the various auxiliaries and the usual air-brake equipment.

The cooling system consists of a three-sided radiator mounted in front of each operator's position, with a vertically mounted motor-driven propeller-type fan for exhausting the air upward from the radiator compartment. A feature of this equipment is the provision for circulating the water in the two radiators in series, thus equalizing the water temperature in the two engines. One of the three sides of the radiator compartment is used for cooling the engine lubricating oil, each engine being provided with a separate oil-cooling system.

The locomotive was built, equipped and tested, for the Ingersoll-Rand Company at the Erie Works of the General Electric Company.

EDITORIALS

Open the Flood Gates!

The mechanical department activities on a railroad are not only widely diversified, but are spread over great areas. As compared to more concentrated industries, only a comparatively thin line of supervision is maintained.

It is essential, therefore, if the best results are to be obtained, that the foremen and supervisors cultivate unusual administrative ability. While it is true that some of the forces are concentrated in considerable numbers in the back shops, even there the number of men per foreman is relatively large. In a car repair yard, in an enginehouse, or in similar operations, the forces are scattered over considerable areas. The wise foreman, and the one who possesses real executive talent, will use his best efforts to draw out and stimulate the special abilities of the men under him. Only in this way can he make a real success of his work.

Too frequently management overlooks the fact that a master craftsman may not possess leadership ability, and because men unfitted for such tasks have been promoted to positions of responsibility, the efficiency and effectiveness of a department may be seriously hampered. The boss cannot know everything about the detailed operations of his department. Only by getting the loyal and intelligent co-operation and support of every man under him, can he secure the best results.

If a boss is a "small" man, if he grabs off credit that belongs to others, he soon shuts off such sources of information and improvement and his department makes a poorer showing than it should. If, on the other hand, he frankly gives credit to his men for the good suggestions and the good records they make, he becomes a bigger man, and, with the enthusiastic co-operation of his subordinates, will establish new and better records of performance for his department. The trouble is that the "small" man cannot recognize that he is standing in his own light when he "hogs" the credit for suggestions made by others.

One of the most successful superintendents of motive power who ever served on an American railroad was Robert Quayle, of the Chicago & North Western. He insisted that the prime reason for his success was the fact that he invariably picked men as his assistants who were bigger than he was. Among his assistants at various times were Edwin M. Herr, who later went to the Northern Pacific as the head of its mechanical department, became general manager, then went to the Westinghouse Air Brake Company, and finally was president of the Westinghouse Electric & Manufacturing Company. Waldo H. Marshall, another of his assistants, later went to the Lake Shore & Michigan Southern as superintendent motive power, advanced to the position of general manager, and then became president of the American Locomotive Company. George R. Henderson was still another of his associates.

The railroads today are in a precarious condition. They have been subjected to the most severe regulation and have had their hands unfairly shackled in fighting their competitors. Now, in the decision in the eastern passenger rate case, the Interstate Commerce Commission is, in effect, attempting to take over managerial functions.

We have a large faith in the future of the American railroads, but it will depend upon real leadership on the part of all the officers and supervisors. The railroads must have the best efforts of every employee. Unfortunately, progress is being held up in many places by peculiar and narrow conceptions on the part of officers and foremen in dealing with the human element.

Men will always respond with the best in them if they are properly encouraged and directed. That the flood gates can be opened up has been demonstrated in the past by leaders who were big enough to listen to the suggestions of men under them and give proper credit for those suggestions which proved effective and really worth while. This at least is a large factor in successful management, either of a gang, a shop, a department, or the railroad as a whole.

Air Conditioning Summarized

On page 184 of this issue appears a table which is a summary of data published in the February, 1934, the December, 1934, and the March, 1936, issues of *Railway Mechanical Engineer* on air-conditioned cars.

The first three columns in Table I show that at the end of 1933 there were 648 air-conditioned cars in service. In the following year 1,872 more were added and in 1935 there were 3,347 more, bringing the grand total up to 5,867 by December 31, 1935. At the end of 1933 about 38 per cent of the cars were Pullmans. In 1934 this increased to 62 per cent. Air conditioning was initiated by the railroads, but the Pullman Company realizing its desirability for de luxe equipment proceeded to install it at a much greater rate than the railroads. At the end of 1935 the Pullman percentage had dropped to 55 indicating that the Pullman Company was getting a large part of its cars equipped and that the railroads as a whole were beginning to broaden the field of application as applied to railroad-owned cars.

During the period from December, 1933, to Decem-

ber, 1935, the percentage of ice-activated cars declined from 46 to 34. During the same time the percentage of compressor type systems increased from 48 to 53 and the steam-ejector installations increased from 6 to 13 per cent.

The data so far available can not be depended upon to indicate future trends, but it would appear that the ice activated cars were installed to meet demands quickly with a minimum first cost and that the compressor and steam-ejector systems have now been developed to a point at which they will limit the application of ice-activated systems and probably replace some of those now in service. It also appears that the railroads can be expected to broaden the application of air conditioning to include almost all types of passenger-train cars. There are now nine times as many cars equipped as there were at the end of 1933 and the bulk of the total does not consist of special service cars but rather of 2,404 sleepers and 1,122 coaches.

Light Weight And Safety

The idea that the new light-weight passenger equipment will actually operate without falling apart and so is safe when operated by itself is gradually being accepted by railroad men. The question still persists, however, as to what will be the result should collision occur between a train of light-weight equipment and one of conventional heavy rolling stock.

It may be stated at once that weight and strength are not necessarily synonymous terms. Where light-weight trains or coaches are designed to meet the same strength requirements as are the conventional heavy cars, the lighter cars for all practical purposes are stronger than the heavy cars. This is because both the energy stored in a moving vehicle and its momentum are directly proportional to the weight.

In the case of a head-on collision between two trains of equal weight moving at equal speeds, both trains are suddenly stopped and their total energy of motion absorbed either through distortion or failure of the parts of the structures. If one train, equal in weight to that opposed to it, is moving at a slower speed or, moving at the same speed, is lighter than the opposing train, it will store less energy and the amount of energy to be absorbed during the impact of collision will be reduced accordingly. Assuming that the structures as a whole do not fail, the surplus energy of the heavier or faster train will appear in a reversal of the motion of the lighter or slower train and the continuance of both at a reduced velocity.

If the time interval during which the impact pressure prevails is essentially the same in the case of a collision between a heavy and a light train as between two heavy trains, the force of the impact will be directly proportional to the weight of the lighter train (force times time equals mass times velocity). In the case of a rear-end collision between two trains of unequal weight, the change of momentum (mass times velocity) following the impact will be the same irrespective of which of the trains is struck and will be less than as though both were equal in weight to the heavier train.

It is evident, therefore, that a reduction in weight of either one or both trains involved in collision impacts effects a reduction in the destructive force of the impact as well as in the energy which must be absorbed. The smaller inertia of the light-weight cars or train, however, will tend to subject such equipment to more violent changes of velocity than the heavier equipment will experience. This may, in some cases, increase the destructiveness of the collision to the lives of the passengers in the lighter cars, although a question of degrees of violence of movement in such cases is somewhat academic. On the other hand, the higher ratio of strength to inertia of the light-weight cars will tend to reduce cases of telescoping, which frequently occur both in head-on and tail-end collisions of passenger trains made up of heavy rolling stock.

On the whole, from the standpoint of safety the sooner and the more extensively passenger-car weights are reduced without reduction in the strength of the design, the safer the equipment will become when accidents occur.

Burlington Experience With Zephyr Trains

Many lessons of unusual interest and importance may be learned from the experience of the Chicago, Burlington & Quincy with four Zephyr light-weight, high-speed trains which have accumulated a total of about 1,000,000 miles up to April 30, 1936, according to an article by President Ralph Budd published in a recent issue of Civil Engineering.

Regarding speeds and schedules, President Budd said that the Twin City Zephyrs, operating at maximum speeds of 90 to 95 m.p.h. and at an average speed of 66.3 m.p.h. for the 431 miles between Chicago and St. Paul, Minn. (including six stops), are usually on time. This statement also applies to the Mark Twain Zephyr and to the Zephyr which operates on the Lincoln-Omaha-Kansas City run. In fact, all four trains have made their schedules 94 per cent of the time, which may be compared with 60 per cent for other passenger trains on comparable runs. These other trains, however, have been no more than 30 min. late 90 per cent of the time.

In response to the inquiry regarding any defects or weaknesses which have developed, Mr. Budd said, "No structural weaknesses or defects of any kind have been disclosed upon continuous and careful inspection. Normal maintenance has been followed. For example,

wheels have been changed and turned; pistons have been renewed; fuel injectors have been replaced and somewhat improved. Structurally the cars have proved faultless . . . The availability for service of the four trains has averaged 97 per cent. This high availability is attained by careful inspection and by replacing the parts that wear out on a definite schedule. On our modern high-speed passenger engines, experience has demonstrated the necessity of establishing a mileage limitation on main driver axles. We were of the opinion that this might be found desirable in connection with the motor axles of high-speed Diesel-electrics and we are making periodic examinations of our motor-driven axles."

The four Zephyrs now in regular operation have experienced nine grade crossing accidents, having struck four automobiles, one truck and one road grader, and been run into by two automobiles and one truck. They have run down many animals, including cattle, horses and mules, on the track between crossings. A study of the 10 months' period ending January, 1936, indicates, however, that the Zephyrs had somewhat fewer accidents per million train-miles than other passenger trains. The vehicles struck by Zephyr trains have been demolished or badly damaged, but no damage has been done to the Zephyrs in any of the highway crossing accidents beyond scratching and denting the stainless steel covering, and the trains have always continued on their runs and made scheduled time. In the only accident involving another train, the Mark Twain collided at a speed of about 20 m.p.h. with a string of Pullmans at a cross-over in the St. Louis yards on March 1, 1936. One of the Pullmans was completely derailed and the front trucks of the Zephyr derailed, but it sustained no damage beyond some scratches; none of its 61 passengers was injured, and the train made its regular run the next morning.

As regards safety, Mr. Budd said that the Zephyrs are strong, free from noticeable vibration, have a low center of gravity, hold the rails remarkably well and are easy on the track. The great strength of the stainless steel construction provides a high degree of protection, and he points out that the light weight of the train contributes to safety by permitting relatively short-distance stops to be made from high speeds. It should be pointed out that within the capacity of the brake shoes to dissipate energy without exceeding the breakdown temperature of the brake-shoe material, the shortness of the stop is not directly limited by the wheel load.

The patronage of the Zephyrs has exceeded expectations, and, in fact, during last July and August approximately 5,000 persons could not secure accommodations on the Twin Zephyrs, each of which has seats for 70 passengers, plus 15 seats in the dining section, and makes a round-trip daily between Chicago and the Twin Cities. Regarding the cost of operation of the Zephyrs, Mr. Budd said, "The cost of operation for 640,942 miles, up to December 31, 1935 (latest data available), was 31 cents per train-mile. This includes everything except depreciation and track maintenance and includes an accrual for power-plant maintenance. It seems safe to say that the cost of operation is substantially less than half that for a conventional train of the same capacity at the same speeds. Actual costs for the Zephyrs and the best estimate for comparable steam trains are shown in the table:

	Zephyr trains	Steam trains
Maintenance of power plant or locomotive..	$0.0504	$0.1830
Maintenance of train.....	0.0399	0.1020
Cost of fuel oil or coal.....	0.0139	0.1085
Cost of lubricating oil and water.....	0.0093	0.0140
Wages of crew.....	0.1735	0.2240
Train supplies and expenses.....	0.0271	0.0640
Total	$0.3141	$0.6955

Comparative riding qualities, Mr. Budd says, are difficult to judge, owing to the higher speeds used, but the articulated construction gives certain marked advantages, including the elimination of side motion at the couplings. This feature, together with the low center of gravity, provides smooth and quiet performance at high speeds, especially on curves. The contour of all the wheels, except the power-truck wheels, have been modified so that they now have cylindrical instead of conical treads, and this seems greatly to improve the riding comfort on light-weight trains. On account of the light axle loads, the life of wheels, even at high speeds, has been satisfactory, the average life being 58,844 miles for the 36-in, power-truck wheels, and 56,490 miles for the 30-in. trailing-truck wheels. The efficacy of the cylindrical wheel tread as a means of removing unpleasant lateral oscillations from the riding of the trains has been demonstrated on other light-weight equipment as well as on the Burlington articulated trains.

In regard to the question of whether or not this type of train will take the place of other trains, Mr. Budd said that some additional conventional steam trains will undoubtedly be replaced by relatively small light-weight streamline trains, but the extent of this replacement is uncertain. In the case of small local trains where it is not imperative to interchange cars with other trains or to pick up or set out cars, the maximum economy, comfort and capacity are obtained by light-weight construction, combined with Diesel power. For larger through trains he says that interchangeability of cars is a necessity and some modification of the articulated construction seems essential. The modification suggested by Mr. Budd has already taken tangible form in the two 10-body-unit trains now under construction for the Burlington. Each train will consist of six cars (independent vehicles). The first two will each consist of a single body unit; the next, of three articulated body units; the two following of two articulated body units each, and the last, of a single body unit. Each of the trains will thus have 16 trucks as compared with 11 had it been a completely articulated unit, or with 20 trucks had each body unit been a separate car.

THE READER'S PAGE

British Post Office Tube Railway

To the Editor:

I quite agree that "Marinac's" cartoons may have considerable attraction for many of your readers. But *where* does he unearth some of the information published in connection with these "Rail Oddities"? Consider, for instance, the one on page 43 of the January *Railway Mechanical Engineer*. In the description on page 44, it is stated that ". . . the train starts off with its load, which is sometimes as much as 300 tons." In an apparently authoritative article on The Post Office Tube Railway, contributed to an English publication by the engineers of the British Post Office, the trains are said to be composed of two or three vehicles, each carrying a load of 1120 lb., or one-half of an English ton. A descriptive note in "Whitaker's Almanack" for 1927 places the maximum carrying capacity of the railway at "45 tons of mails per hour in each direction". Perhaps 300 tons represents the total amount of mail handled through the subway in the course of an average day.

Wm. T. Hoecker.

[Mr. Hoecker's surmise seems to be correct—Editor.]

"Jim Evans" Finds a Backer

To the Editor:

In the April *Railway Mechanical Engineer* an article appears on the Readers' page signed "A Car Foreman" in which "Walt Wyre" and his "Jim Evans" are taken to task for their apparent mismanagement and poor judgment and control of the roundhouse foreman's job.

After careful perusal of the car foreman's letter it is evident that he has never had any roundhouse experience. There is no comparison between a car job and a locomotive job. To the average locomotive employee a loaded seventy-ton car would be a toy compared to a modern locomotive ready for service and weighing over 400 tons. He says that the "head end" think they are the whole railroad, and goes on to say that the locomotive and crew are just added expense to the road. Let him try throwing the engine out of his automobile. He will eliminate the expense of gas and oil and engine repairs but unless he can coast down hill all the way or use a sail for power he won't get very far.

I did not notice that Jim Evans had done any crying on anyone's shoulder. As the emergencies developed he just put his shoulder to the wheel and kept things rolling along. By the way "A Car Foreman" writes I imagine he holds one of the few snap jobs that may still be left on the railroad. Wait until the efficiency engineers find his hiding place and trim his gang down so that even some of the bone is whittled away.

There is a feeling expressed in his letter which I think has a great deal to do with some railroad inefficiencies today. That is an inter-department rivalry, which is not healthy constructive criticism but more like the opinion of a competitor. Attend a supervisor's meeting and you will soon get the idea. There is a great deal of talk about cooperation between the various departments; you leave the meeting all enthused and start "cooperating," but you soon find yourself on the giving end only. It appears to be a single track with one-way operation only—that is away from you, no returns.

What is needed is a closer relationship between the various departments. Cooperation is O.K., but there are no teeth in this kind of mutual agreement; many men must have a penalty hanging over their heads before they will perform certain classes of duty.

There is much talk and argument regarding railroad consolidation. The railroads as a whole do not need to be consolidated, but as I see it the various departments in each railroad should have a closer coordination with each other. To show what I mean, draw up a chart of the organization of any large railroad system and after completing this family tree, trace back any branch and note how far back you have to go before you reach the connecting link with any other department. It is generally so far away that effective contact to bring about cooperation is out of the question. The supervisor on the job has his feet in the mud while the connecting link at the top of his branch has his head in the clouds.

I would like to congratulate the car foreman on his optimism and good management as expressed in his letter, but would ask him to show a more sympathetic attitude to his brother railroader in the roundhouse. We are both essential cogs in the great railroad machine, and must work together in true harmony in order that railroading may continue to prosper and live up to its traditions.

Roundhouse Foreman.

Spot-Welded Gondola Car

To the Editor:

With reference to your question following Mr. Havemeyer's letter on page 154 of the *Railway Mechanical Engineer* for April, 1936:

On page 853 of the Railway Review for December 14, 1918, you will find an illustrated description of a spot-welded gondola car built for the C. B. & Q.Railroad, by the American Car and Foundry Company, at St. Louis, in November, 1911. The following paragraph is quoted from the Railway Review article:

"Owing, however, to the inaccessibility of some of the connections and to the use of a considerable number of castings, as in the case of the door hinges, etc., only about 85 per cent of the fabrication was effected by means of the welding machine, rivets being resorted to for the remainder. In the underframe, welding was used on the center sill and cross-brace cover plates, and in the end sill and the body-bolster assemblies. With the exception of the ladder irons, it not being desired to risk human life by attaching them by a process admittedly experimental, the entire superstructure was assembled by the spot welding process."

At the time the article was published, the car had been in every-day service for seven years and was said to have made a very creditable record.

William T. Hoecker.

Gleanings *from the* Editor's Mail

The mails bring many interesting and pertinent comments to the Editor's desk during the course of a month. Here are a few that have strayed in during recent weeks.

Jim Evans Liked in England

I might add that the stories concerning Evans, the roundhouse foreman are much liked; they make a very good leavening to a thoroughly practical journal.—*From an English correspondent.*

Blowing Down Locomotive Boilers

Railway conditions in England are so different from those in America that the solution of problems in some instances is not necessarily the same in each country, but on other matters an interchange of information is certainly beneficial. Take, for instance, the vexed question of blowdown for locomotive boilers; there is considerable variation in ideas as to whether continuous or intermittent blowdown is best, and as to whether the blowdown should be taken from just below water level or from just above the foundation ring.

Treating 'Em Rough

I heard the following in a certain factory the other day:

"Well! How in ——— did you come to do it, eh?"

"Well, Mr. Smith, it was like this. I thought you said——."

"Thought! You thought? Who the hell pays you for thinking? You're not supposed to think. I'm here to do the thinking. You've made a nice mess of things and I'll attend to you a little later. In the meantime go back to your work."

Then turning to me, he said, "That's the way to tell it to them."

I don't think so. But I wonder if there are any of these foremen left on the railways, who'd tell a man he was not supposed to think. I'm happy to state this was not a big shop, but a so-called high production outfit, and I don't think my foreman friend likes me any more.

Education—Not Repression!

There can be no question that the events of the past seven years have left many railroad men in such a state of mind that some stimulus is needed to lift their vision above and beyond the daily round of humdrum tasks, to inspire clear thinking and to develop a broader viewpoint. Now that we are beginning to emerge into the light again, your unqualified support of the minor mechanical department associations is certainly a well-timed step in the right direction. You are particularly to be commended for openly opposing those who intimate that the members of the smaller associations have sometimes talked too much without being fully conversant with all phases of their subject. Such happenings have been too rare to serve as a pretext for condemning the associations. To be sure, infallibility is not a characteristic of human nature. Occasional inadvertent indiscretions and errors will always be committed, even by those charged with formulating the broader policies of railroading. The remedy for these offenses is education, not repression.

Patent Medicine Stuff

There was a time in the darkest days of the depression when I thought the advertisers were going to have to resort to testimonials and sworn before a notary stuff in order to get the doubtful ones to make a purchase. After all, you know there is nothing like testimonials to sell things—kidney pills, patent medicine or your favorite brand of indispensable cigarettes.

If Mechanical Associations Are Discontinued—What!

If the minor mechanical associations are not to be revived, then something else must be devised to take their place. Railway mechanical engineering is in itself a distinct profession, actively practiced by a large body of able and intelligent men. Under the conditions prevailing in this age, these men cannot remain indefinitely without a forum for the discussion of their problems, the interchange of ideas, and the diffusion of mutual inspiration. Some consideration might be given to the formation of an organization similar in scope to the Institution of Locomotive Engineers, which has attained high prestige in Great Britain and elsewhere. Its meetings are held frequently in various centers, in addition to London. The papers cover the entire range of activities of the mechanical department, and the discussions, stimulated by the circulation of advance copies of the papers, are every bit as valuable as the papers themselves. There are several grades of membership, embracing all occupations from apprentice to chief mechanical engineer.

* * *

For explanation see page 224

With the Car Foremen and Inspectors

Upholstery Work at Beech Grove Shops

A large volume of more or less routine operations in cleaning, repairing and rebuilding passenger car seats, as well as making new seats, is completed annually in the upholstery department of the Big Four passenger-car shops at Beech Grove, Ind.

This department, located on the second floor of the mill-room building, is spacious, well lighted and equipped to produce an unusually satisfactory output, both from the standpoint of quantity and quality. Contrary to usual practice, the efficient line-up of tanks, drainboards and scrubbing equipment for cleaning the seats is located in one end of the upholstery department itself. In addition, this department has been provided recently with a modern hair-picking machine which can be operated without producing objectionable dust, owing to an effective exhaust hood and pipe installation. All of the operations in connection with the reconditioning of passenger-car seats, with the exception of air blowing, are thus concentrated in a single room where they can be more readily supervised and the labor of handling minimized.

Cleaning Cushions

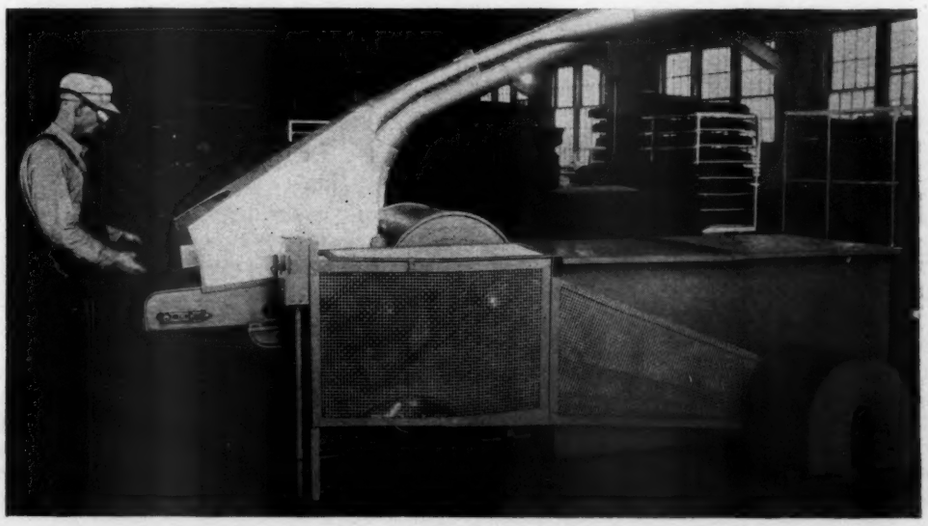
After being removed from cars in the coach shop, seat cushions and backs are piled on trailer trucks and taken to the large wood dusting-table, just outside of the mill-room building, where as much dust and dirt as possible are blown out, using a hose and straight pipe nozzle, with air at the shop-line pressure. Still carried on the trailer trucks, the seat and back cushions are moved into the shop and up the elevator to the cleaning position in the upholstery department. Here they follow practically a straight-line movement. They are dipped in a cleaning solution, placed on a drainboard for a few minutes, passed through a rotary brushing machine, dipped in a dyeing solution if necessary, again placed on a drainboard and finally are loaded in a special cushion wagon for movement to the dry room.

The cleaning solution is a mixture of about 1½ pt. of renovating cleaner to 40 gal. of lukewarm water. The rotary swing-type brush, belt-driven from an overhead electric motor, is used to make several passes over the cushion and spin out all oil, dirt, soot and grease. The dye tank is filled with 30 gal. of water and slightly over a quart of dyeing solution. This solution is brought to a boil and allowed to simmer while the cushions are being dipped. Both the cleaning and dyeing tanks are metal lined and the metal-covered drainboards are arranged to drain back into their respective tanks.

The dry room, into which the cushions are moved on the special wagon, is heated by steam pipes in the usual manner and insulated with ¼-in. sheet asbestos in the sides and 6 in. of plastic asbestos in the roof. With a temperature of about 200 deg. F. in this dry room, the cushions are thoroughly dried in from two to three hours. Using the method and equipment described, one man can clean approximately 1½ car sets, or 63 seat cushions and 63 backs in eight hours.

The Upholstery Shop Facilities

The steel cushion and back wagons used in the Beech Grove upholstery department are a comparatively new design. The back wagon, shown at the left in one of the illustrations, consists of a welded steel frame 87 in. long by 39 in. wide by 60 in. high, supported on 11-in. ball-bearing wheels, two of which are mounted on an axle arranged to swivel under the pull of the handle used in steering the wagon. The bottom frame of this wagon consists of 2½-in. by 3-in. angles, the upper frame being made of 1¼-in. angles, with intermediate angles dividing the wagon into six sections. The seat backs rest on pan sections 4 in. wide with ½ in. upward-extending flanges. These pans are welded to the lower

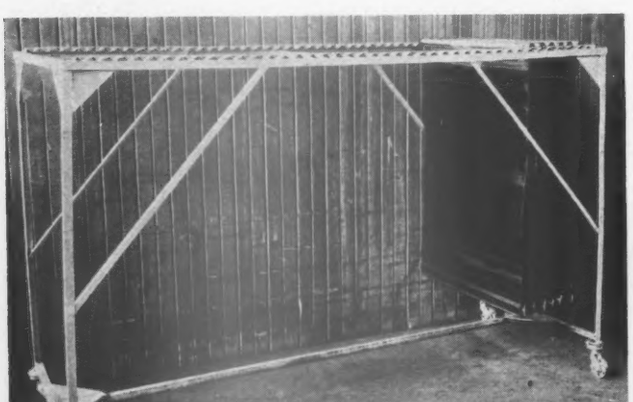


The rotary-type hair picker is provided with an effective dust exhaust system and with a well guarded motor belt drive

Passenger seat cushions in various stages of repair and rebuilding

and intermediate horizontal angles. The backs are held in a vertical position by intermediate horizontal metal strips at each section. The total capacity of each wagon is 20 seat backs.

The cushion wagon, shown at the right in the illustration, is similarly made of a welded steel frame 110 in. long by 39 in. wide by 60 in. high. This frame is divided into three vertical sections, the two outer ones holding 16 seats apiece and the center section 8, or a total of 40 cushions. Each of these cushions rests on a pressed 1½-in. by ½-in. angle, made of No. 14 gage steel, welded



Light and easily portable curtain rack, comprising a welded steel frame mounted on four ball-bearing swivel castors

in a crosswise position and spaced 19 in. apart to accommodate the standard cushion width. Cushions and seat backs are kept in these wagons during their entire handling in and about the upholstery shop.

Still another convenient material-handling device, used at the Beech Grove upholstery shop, is the portable curtain rack shown in another illustration. This consists of a welded steel frame 79 in. long by 29 in. wide by 44 in. high, supported on four 3-in. ball-bearing casters, each of which swivels to permit ready movement of the rack in any direction. The steel frame is made of 1-in. angles welded together and stiffened at the corners by triangular gussets. In addition, four diagonal braces, made of ¾-in. angles, are welded at an angle of 45 deg. between the corner posts and the upper horizontal members to give additional stiffness to the frame. Two steel strips, made of No. 10 gage material and provided with 42 corrugations per strip, are welded to the upper horizontal members. The curtain rollers are dropped into these corrugations and held in place against endwise movement by a wire arc welded along the top of each strip and spaced slightly wider than the length of curtain rollers.

The hair-picker has been equipped with a special electric motor drive and dust exhaust system. Hair, tow or moss are fed into this machine by hand. An endless belt, 24 in. wide, conveys the hair to a pair of special rolls which pass the hair slowly into the machine proper, where a rapidly revolving 22-in. cylinder picks the hair apart, loosens any bunches and produces a uniformly light mass of hair. A perforated metal plate under the picker cylinder serves to screen out any heavy dirt particles which fall on it, but the most of the light dust and dirt are drawn out of the machine by means of the exhaust system.

The hair passes on through the picker into a metal box

Light but strong welded steel wagons used in handling seat backs (left) and cushions (right) in the upholstery department

72 in. by 30 in. by 36 in. equipped with a wire mesh in the bottom, which also is used to screen out any small amount of remaining dirt which settles to the bottom of the hair storage box. The easily removable top cover gives access to this box, from which the hair can be supplied to the upholsterers as required.

A feature of this machine is the exhaust system, by means of which a 6-in. pipe draws dust out of the picker

cylinder housing. A sheet metal hood and 3-in. pipe connection to the exhaust system disposes of any dust occasioned by placing the hair on the endless belt at the receiving end of the machine. The machine is driven by a 5-hp. electric motor, with belt drive to the picker cylinder pulley. A neat sheet-metal guard is placed around the motor and a heavy wire screen guard around the driving belt and pulleys.

Method of Handling Cushion Repairs

After being thoroughly cleaned and dried, the seat cushions and backs are moved on the special wagons into

Swing-type rotary brush, tanks and drainboards used in washing car seat cushions and backs

the upholstery department proper, where further careful inspection and repairs are made. On heavy repairs, the seat cover is removed and the cushion dismantled as much as necessary to get down to defective parts, which are either repaired or renewed. Complete rebuilding of the cushion, not normally required until after 10 to 12 years of service, consists of checking the condition and position of springs in the steel frame, application of spring-steel strips on top of the springs, and application of canvas strips over these steel strips to protect the spring canvas, which is glued to the frame at the edges and tacked at the bottom. A canvas-covered hair-felt roll is next applied, with about 1½ lb. of hair per cushion on top; this is held in place by muslin tacked to the wood tacking strips. The cover of plush or other material, with the corners sewed beforehand, is applied over the cushion and tacked in place at the bottom. A seat cushion in various stages of repair is shown in one of the illustrations.

In many cases light repairs only are necessary, such as sewing up a few small holes, applying missing tacks, etc. For intermediate repairs, whenever the canvas cover is cut, liners are put underneath and the ends glued to the old canvas, thus avoiding the complete stripping of the cushion and renewing of the entire canvas. A great saving in time and labor as well as material is effected by this means.

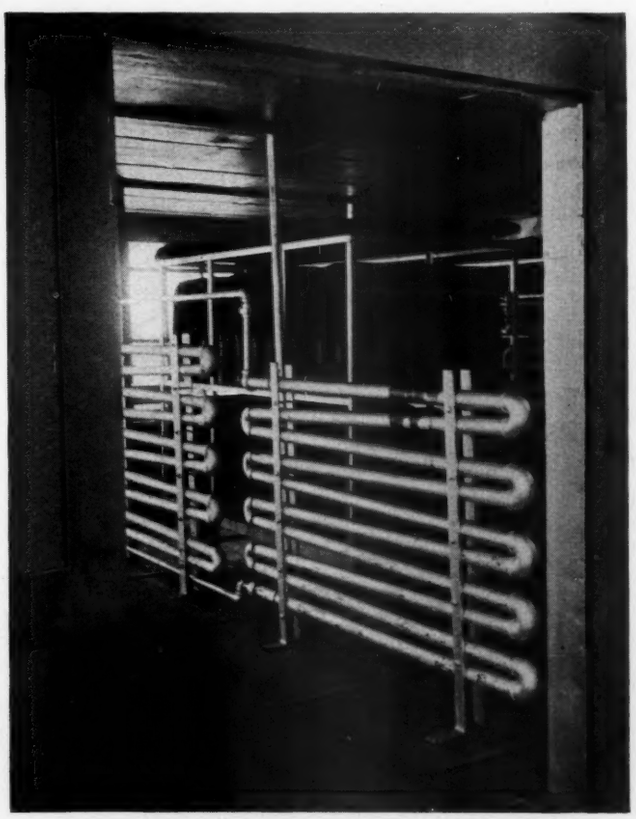
In cases where the plush is badly worn, both it and the muslin are removed and additional hair applied. The muslin is put on again if in good condition and a new cover applied. When the cushions are worn on the ends, the covers are removed and new side strips sewed in place to cover this defect.

In repairing the seat backs, the moldings, made of ⅝-in. reed, covered with plush, are renewed when worn out. If the back plush is badly worn, it is removed and new covers are prepared for application. If the canvas is torn, the backs are completely stripped down and rebuilt, as liners cannot be applied. Approximately 2½ lb. of hair per back are required in rebuilt car-seat backs.

Curtain and Carpet Repairs

The operations in reconditioning passenger-car window curtains are as follows: The curtains are brought to the upholstery department and the shoes and cover plates removed. The fabric then is washed with a hand brush and soap and the curtains dried on the special wagon previously described. After being removed from the dry room, curtains are equipped with thoroughly cleaned and rebronzed cover plates and shoes. In case curtain fabric needs renewal or sewing, it is taken off and either new curtain material or material that has been repaired is used in refitting the cars.

Carpets usually require renewal at intervals of about 18 months. If to be reapplied, each carpet is dusted and washed, using a soap-powder solution which is subsequently sponged off with clear water on the wood bench



Steam-heated dry room, with insulated sides and roof and angle-section floor tracks to guide the wheels of cushion or back wagons

outside the shop building. The carpet is sewed and stretched on the usual type of carpet rack.

Additional work handled at the Beech Grove upholstery shop includes the manufacture of large quantities of locomotive cab curtains, arm rests, seat cushions and backs. Diner and lounge chairs are repaired and rebuilt at another shop, but Beech Grove handles a considerable amount of miscellaneous work such as repairing mail bags, patching diaphragms, etc.

"Whoever invented arch-bar trucks ought to build one more contraption, then quit," Jake growled

NOTHING UNUSUAL

THE car department of the S. P. & W. at Plainville is not the largest on the system by any means, but when it comes to getting trains over the road, it's mighty important. Most of the business is gold ball through stuff that has to keep moving—fruit and vegetables from California and Arizona, cattle and sheep from Texas, New Mexico, and Arizona, with a potential damage claim riding the waybill of every car of stock or perishables that passes through Plainville.

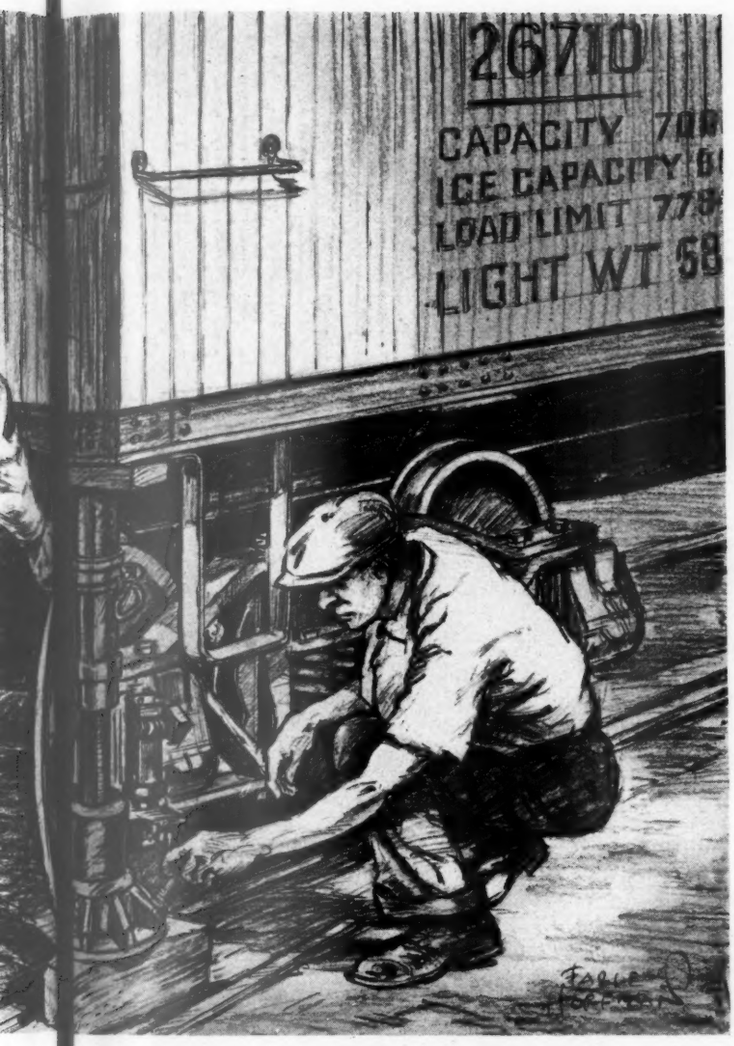
A large portion of the cattle is interchange from the C. T. & W. that crosses the S. P. & W. at Plainville. The C. T. & W., officially Colorado, Texas, and Western but usually referred to by S. P. & W. men as the Count Ties and Walk, runs right through the middle of the "dust bowl area." Any car inspector that has tried to inspect one side of a ninety-car train during one of the sand storms won't wonder why newspaper men have named that district the dust bowl area. At times the dust is so dense that it is impossible to see a lantern two car lengths away. Dust gets in everything. Dick Wheeler, the car foreman, says dust even gets inside the light bulbs at times. Perhaps that is a slight exaggeration, but it does get in journal boxes. Sand mixed with car oil makes a better abrasive than lubricant.

Most of the cars that come in from the C. T. & W. usually have plenty of sand in the boxes and are plenty hot. It's no fault of the "Count Ties & Walk." Some of the cars set out by a stock pen remain days at a time waiting for a rancher to make up his mind to ship. The stock pens as a rule are located on the open prairie with nothing to stop the sand until the cars are set out. It is not unusual for the local crew to have to shovel sand off the rails and from around the trucks before a car can be moved without getting on the ground. Some of the dirt gets in the boxes.

After the rancher makes up his mind to ship, then he gets in a hurry. Soon as the cattle are loaded he sits down by the telephone and doesn't leave it until the cattle are safely delivered at Kansas City; and does he howl if there's a delay!

Besides the perishables and cattle, the S. P. & W. handles quite a bit of oil from the branch line that taps the mid-continent oil field. Pipe lines are taking most of the business from the big companies, but most of the small independent companies ship by rail, usually not enough at the time to make a train, just half a dozen or so cars; but one car limits train speed and makes it necessary to cut down on time spent in the terminal if trains are to make schedules promised shippers and avoid damage claims.

That's the freight business at Plainville, the stuff that pays the bills and keeps men on the payroll. The pas-



by Walt Wyre

senger business is right down the same alley, high-ball stuff everybody hears about if there's a delay—two through trains each way running on schedules that don't allow a minute's lost time to be regained.

DICK WHEELER, the car foreman, looked through the morning mail, laid aside letters to be answered, read the lineup, and strolled down to the car shed to see how things were getting along. He found Jake Miller, a carman, swearing and sweating because a jack he was using wouldn't work. Jake and his helper were working on a "reefer" loaded with lettuce—broken arch bar.

"How you getting along, Jake?" Dick asked.

"Not worth a damn!" Jake glared at the defective jack. "Why can't we get some jacks, anyway?"

"We've got some ordered, had them ordered three months. Four have been sent in for repairs and haven't got them back yet. I'll rush them on 'em."

"Whoever invented arch-bar trucks ought to build one more contraption, then quit," Jake growled.

"Well, we ought to be pretty well rid of them in a couple more years," Wheeler told him. "I'll send Tom Blake over to help you. We have to get this car on 82, you know," he added.

Dick walked on through the shed. The switch engine was shoving in three tank cars, each bore a bad-order card; steam coils leaking on two of them. That meant steaming out the interior of the tanks before it would be safe for a man to work in them. Take a man all day to do it. Wheeler swore softly. He took a turn through the rip and back to the office. Before he got there he heard the phone ringing insistently.

"Hello.... Yes, this is Wheeler," he answered it.

It was the trainmaster on the other end of the line. "Been trying to get you thirty minutes," he said peevishly. "We've got ten cars of cattle coming in from the C. T. 'bout 2:30; want to get them on 82."

"Eighty-two is doped to run at 3:15," Wheeler reminded him, "and No. 10 will be in at 2:50 and we only have two inspectors on duty."

"Well, I want to get those cattle on 82 and there must not be any delay. There'll be five cars of oil on the train. That'll hold him to a forty mile limit to Sanford; they'll set out there. But it'll push them to make connection in K. C."

"O.K., we'll try to get them," Dick told him and hung up.

The car foreman sat down at his battered desk and started to make out his reports. Just as he was all set the laborer that carried material came in.

"Say, Mr. Wheeler, the storekeeper said he needed some help to load a car of wheels and he'd like to get them blocked soon as they're loaded," the material carrier said.

"All right, tell Thompson and Horton to give him a hand. Tell him to let me know when he's ready to block them; I'll try to find a carman to do it, but I don't know where." Wheeler went back to his office work.

Things went along fairly quiet until noon and he managed to get most of his reports made out, together with writing requisitions for material, answering the phone, deciding whether a pair of slid flat wheels on a foreign car should be changed out or allowed to go and a dozen other interruptions.

WHEN Wheeler returned from lunch there was a bluish haze in the northeast, a low lying bank that in most places would have meant rain, but not in Plainville—in March. It meant sand.

"Hope it don't hit here." He spoke aloud to assure himself that it wouldn't, but without success. After the one o'clock whistle blew Dick made a tour of the rip track to see how everything was going. He found all the men working and on hot jobs, none that could be held a minute longer than necessary without explanations being in order. While he was on the rip, the messenger from the office came by and handed him a message from the superintendent. "Beginning March 16th, will want four cars for loading carbon black each day until further notice," the message said.

Wheeler read the message the second time and reached

up and pulled the lobe of his right ear. It was a habit of his when annoyed to pull his right ear.

Carbon black is just about the most aggravating lading that ever vexed a carman —finer than flour, more crawly than wheat, and light enough that it won't settle. Carbon black is really just soot made by burning natural gas with very little air. Wheeler didn't know how he was going to be able to get four cars a day ready without putting on extra men, but it had to be done. About as much chance of getting extra men as a jack-rabbit would have in a dog kennel. Wheeler gave his right ear another tug and went back towards the office.

By the time he reached the office, the bank in the northeast had become a well defined cloud, black and menacing. The air was still, so still that there didn't seem to be enough to breathe. English sparrows were twittering uneasily around the eaves of the office looking for a hiding place.

Wheeler went in the office and picked up the telephone. He called two inspectors that were due to go to work at four o'clock. It meant overtime to explain, but that was better than delays.

THE sand storm and 82 reached Plainville at about the same time, 2:15, and it was hard to tell which whistled the loudest, the engine on the freight or the swooping wind. Dick adjusted a dust mask over his mouth and nose, put on a pair of goggles, and headed out in the sand storm. Facing the wind, he leaned forward so far that if it had stopped blowing suddenly he would have fallen. The sun was completely hidden by the impenetrable mass.

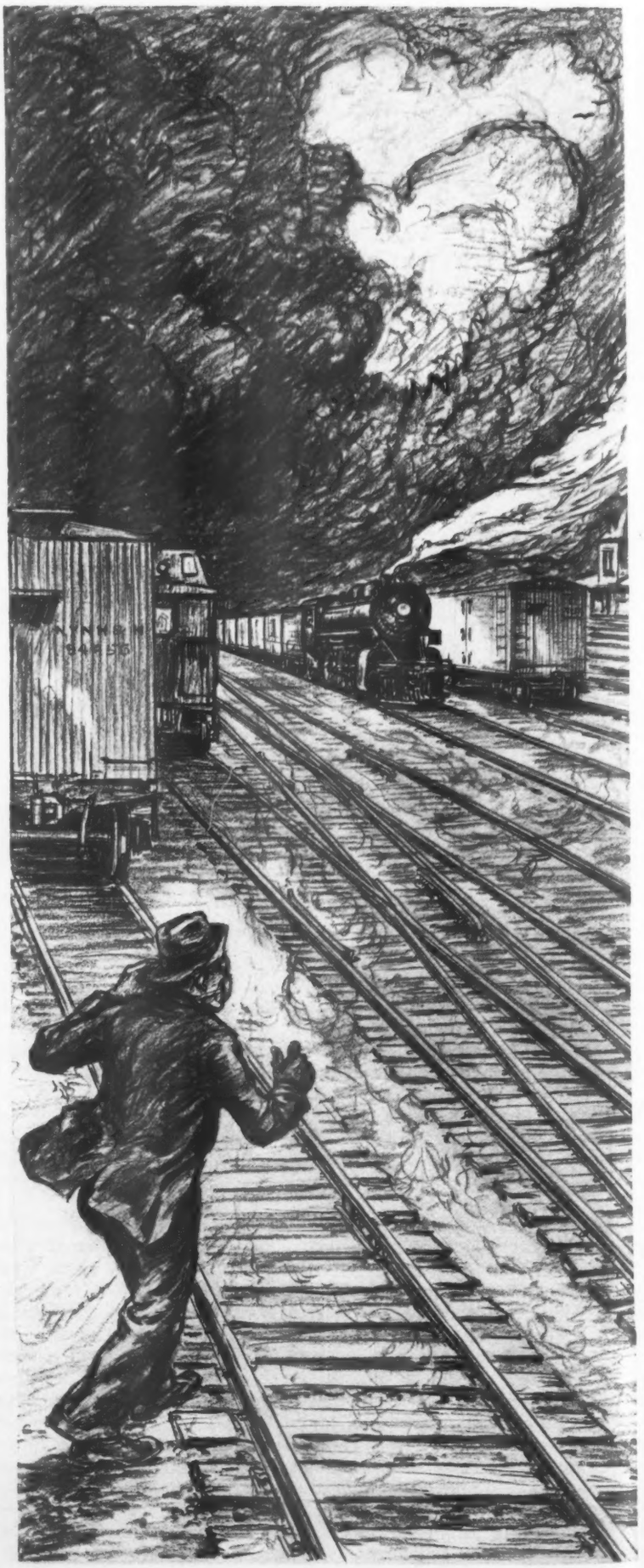
The two first-shift inspectors had already started inspecting the train of reefers when Dick got there. About every fourth car had arch-bar trucks. He hoped there were none broken, and if there were, he hoped the inspectors would find them. They were doing their best, inspecting every one, using flashlight and mirror to inspect the inside.

"Don't seem like that soil-erosion bunch are having much luck stopping the sand blowing," one of the inspectors remarked.

"Wait till they get them shelter-belt trees planted; that'll stop it," the other inspector said sarcastically.

"I've called the two second-trick inspectors. They'll get the passenger. Look 'em over good. Soon as you finish, get that bunch of stock cars. They ought to be in any time now," Dick said and started towards the passenger station.

He met the two second shift men down by the shack. The three of them went to the station. When Dick came down from the dispatcher's office where he went to inquire about No. 10, the switch engine



The sand storm and 82 reached Plainville at about the same time

was coming in on the wye with the cattle cars. He knew by smell and sound, for it was impossible to see that far. The screech of flanges against the rail reached his ears followed closely by the acrid odor of burning dope that assailed his nostrils.

Dick looked at his watch. Two-forty; just fifteen minutes until the passenger would be due. He jerked his right ear and headed back to the rip like a schoolboy going to the circus. The wind was with him and he made good time.

"Get a couple of buckets of dope and beat it down to the east end of number three track," he told a helper. "Bring along a can of oil, too. Tell Morris to come along with you and give you a hand," he added mentioning another helper.

No. 10 rolled in five minutes late. If it hadn't been late, it would have beat Dick to the station. He was puffing almost as hard as the locomotive when he got there. The trainmaster, watch in hand, was backed up against the wall of the passenger station. The inspectors started at the head end of the train. By the time the engine was uncoupled they had the blue flag out and were looking the train over.

In the meantime the wind was doing its best to move all unattached real estate to the southwest part of the country. Passengers peered anxiously through semi-opaque windows and squirmed uneasily in their seats at what they felt to be an unnecessary delay.

"What you think about this brake hanger?" one of the inspectors called out to the car foreman.

Wheeler didn't hear him but understood his gestures. He rushed over to look at it. Pins were badly worn and cotter keys didn't look any too good, worn and loose in the holes. "Give me some cotter keys and go ahead. I'll get it," the foreman told him.

He knocked the cotters out. They were worn almost through. If the inspector hadn't noticed it, chances are vibration would have finished the job before the car reached the end of the run 1,500 miles away. If the key sheared, the pin was certain to work out and let the brake beam drop down. Lesser things have derailed passenger trains and the passengers thought the time used to inspect the train to insure their safety an unnecessary nuisance.

Wheeler put in new cotters and spread the points. "About ready to go?" the conductor asked as Dick came out from under the car.

"Not quite; soon as the inspectors get around."

"Well, we're due out now," the conductor reminded him a little impatiently. "And by the way, the lights don't burn in the lounge car."

"Why didn't you wire ahead so we could have the electrician meet the train?" Wheeler asked the conductor.

"Oh, never thought of it. Just thought is was some little thing you could fix without much trouble."

It so happened the inspectors had already found the trouble with the lights; the generator belt was missing. Dick told them to let it go. He put a train-line connector on and made a note to wire the next division point so they could be prepared to put on a belt.

No. 10 pulled out five minutes later than it was when it came in. If it had been delayed ten minutes, the trainmaster would have had St. Vitus dance from the way he was jerking around.

When the engineer blew his whistle in response to the inspector's signal to release the air, Wheeler started over to number three track to see how things were getting along on the stock cars. They weren't getting along so good. There wasn't a cool box on them. Two new brasses had to be put in, half a dozen had to be repacked. The rest could be made to run by stirring up the packing and adding a little oil. At least Wheeler hoped they could; he was taking the inspector's word for it.

They had finished looking over the cars and were at work getting them ready to go. The helpers had brought brasses and jacks and had one of the jacks in place. The rest of the train was made up and waiting. The switch engine was on the spot nearby panting impatiently. The yardmaster and switch crew crouched on the lee side of the engine waiting for the carmen to finish. When Wheeler gave them the high sign, they climbed leisurely on the engine as though they had all the time in the world. The delay, if any, would be charged to the car department, so why should they worry. At that, 82 got out less than fifteen minutes late on the call and made the run without a car having to be set out on account of a hot box.

A westbound drag pulled in before they finished with the cattle cars. The inspectors would have plenty to do. The car foreman told the helpers to look after the tools and he went back to the rip to figure out how he could manage to get four carbon black cars a day.

At five o'clock the carmen on the repair track went home. Wheeler had some letters to answer and reports to get out. It was after six when he finished. The sand storm passed over and the air was fairly calm when he reached home.

"How did things go today?" Mrs. Wheeler asked her usual question.

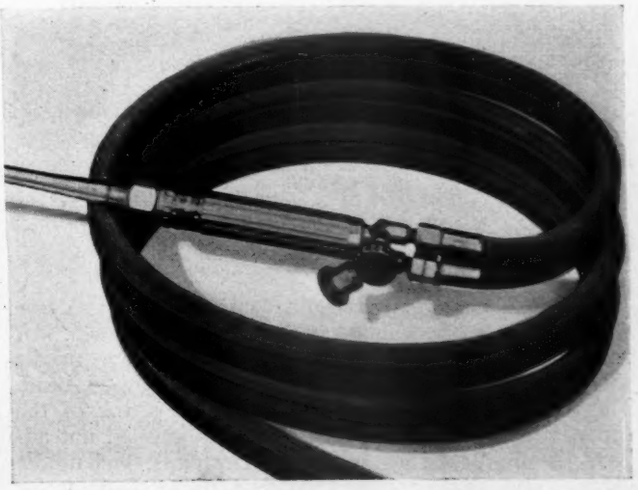
"Oh, 'bout as usual, kinda busy," Dick replied.

"Well, if you had to keep house with all these sand storms, you wouldn't be so calm about it," his wife said.

"Yeah, must be pretty bad," Dick agreed.

Duplex Hose for Gas Welding

A type of rubber tubing or hose of unique construction has been developed by the Electric Hose and Rubber Company, Wilmington, Del. It is especially designed for gas welding and cutting equipment and similar services. In its construction twin hose are simultaneously molded with a connecting web between them, so that a cross-section resembles the figure 8. A single length of this non-kinking hose is all that is necessary for equip-



"Supero Siameez" duplex hose for gas welding work

ment which heretofore has required two separate lengths. This hose is of "Supero" construction, with a special cord-wound reinforcement between the first and second braid, giving it a much higher bursting limit than ordinary welding tubing—with the ¼-in. size the bursting pressure is 2,000 lb. per sq. in. This construction permits the use of differing pressures in the two sides without torque or writhing.

"Supero Siameez" hose is made with the individual conduits in different colors—red and black or red and green, for example—or with both the same color. The connecting web may be easily cut down with a carborundum wheel the distance required for attaching the hose to separate outlets.

New Type Paint Spray Gun

The Paint Spray Equipment Division of the Alexander Milburn Company, 1436 W. Baltimore St., Baltimore, Md., has announced a new paint spray gun, known as Type MM. This gun is so balanced that it is easy to shoot a smooth, even spray exactly where wanted. Coverage and shape are controlled by merely turning two simple knurled nuts.

Cleaning is a matter of a few seconds only as every part touched by the paint is in the single-unit detachable spray head which is made of drop forged bronze. The gun handle and body are one piece, die cast aluminum alloy. A standard air hose connection, located at the base of the handle, is designed for ease of handling and to prevent tangling of the hose or obstructing adjustment controls.

Milburn Type MM paint spray gun

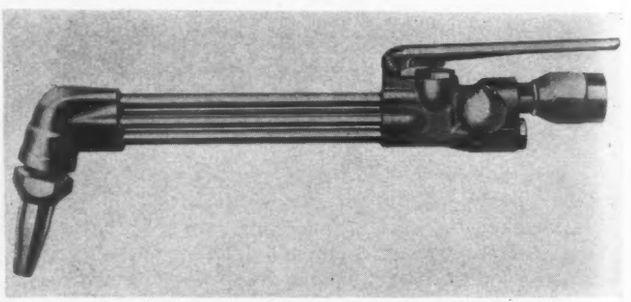
The two-finger grip trigger conforms to the shape of the fingers, responding to the slightest touch. A knurled adjusting nut operates a non-corrosive needle valve to regulate the air flow to the atomizer head. This controls the spray volume and the shape of the spray, whether flat or round. Another knurled nut adjusts the fluid flow by means of a stainless steel needle valve. This valve is connected by a universal joint for constant alignment and easy replacement of paint needle valve points. The valve is closed by a tension spring.

Fluid and air control valves are set so that when the trigger is pulled, air is first admitted into the spray head, then the fluid; when trigger is released the fluid needle valve closes first, then the air valve. This prevents weeping or spattering when the fluid is turned on. The fluid connection is conveniently located beneath and is a part of the detachable spray head.

The Milburn Type MM spray gun is satisfactory for either siphon or force feed and utilizes all types of spraying materials, including synthetics and emulsions. It is recommended for work where wide, perfectly atomized spray and large capacity is required.

Oxyacetylene Cutting Attachment

An oxyacetylene cutting attachment, known as the Oxweld Type CW-22, has been announced by the Linde Air Products Company, 30 East Forty-second street, New York, N. Y. This cutting attachment incorporates features of design and possesses a range of performance which permit it to handle light sheet metal as well as all but the heaviest work at speeds equal to those of the full-size cutting blowpipe. The Type CW-22 attachment operates on either low-pressure or medium-pressure acetylene and can be used on either the Oxweld Type W-17 or W-22 welding blowpipe handle, thereby extending the utility of these two blowpipes.



Oxweld Type CW-22 cutting attachment

Sturdy, smooth operation at all pressures is said to be given by the new streamline injector and by the improved type cutting valve, with removable seat, centralized under the cutting lever. The mixed-gas passage is formed by three Ambrac tubes. The length and the four 90-deg. changes of direction afforded by this type of construction give exceptional flashback resistance. The body and head of the CW-22 attachment are designed to combine strength and lightness. The body is of pressure-forged bronze while the head is a manganese bronze forging.

BROTHERS' SERVICE RECORD—The four Urquhart brothers of Roanoke, Va., all employees of the Norfolk & Western, challenge any four brothers on any railroad to beat their service record. The brothers have a combined total service of 175 years. L. H., 66, a gang leader in the Roanoke shops and the oldest of the quartet, started to work for the N. & W. when he was 19. He has a record of 47 years. G. A., 64, a gang leader in the shops, also started to work for the railroad when he was 19. He has a service record of 45 years. L. D., 62, an engine carpenter in the Roanoke shops, likewise entered N. & W. service at 19. He has worked for the railroad 43 years. C. E., 61, a passenger conductor on the Shenandoah division, was 21 when he started to work for the railroad. He has served 40 years. If the four brothers work to the retirement age of 70, they will have served the Norfolk & Western a total of 202 years.

IN THE BACK SHOP AND ENGINEHOUSE

Relining Rod Bearings By Centrifugal Process

*By L. E. Grant**

Failures of the connecting-rod bearings in the engines of the gas-electric cars on the Chicago, Milwaukee, St. Paul & Pacific have been troublesome. This problem became more acute on the Milwaukee several years ago after the cylinders had been increased one-half inch in diameter. The bearings, which are 80-10-10 bronze lined with a high-tin babbitt, could not be increased in size to compensate for the heavier loading. Most of the failures occurred near the center of the top half and were due to the babbitt cracking or chipping out locally in this zone. A few failed due to the babbitt separating from the bronze back, the separation beginning near one edge. The majority of the failures were in bearings relined in the shop but some occurred in new bearings purchased for these engines.

Consideration was given to the idea of having the manufacturer reline the old bearings but this was found to be practically as expensive as buying new ones. Purchasing a new set of bearings every time the engines

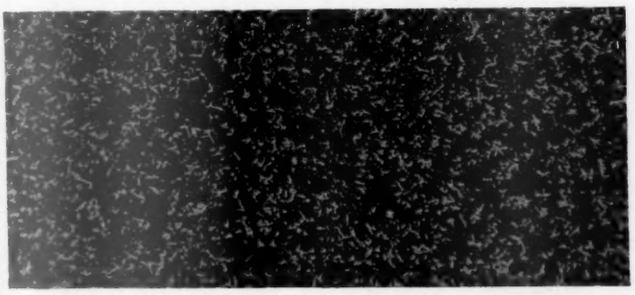


Fig. 1—Microstructure of centrifugally cast babbitt

were overhauled did not appear to be justified; it seemed as though it ought to be possible to devise a satisfactory method of relining these bearings. Some experiments, accordingly, were undertaken to see if this could not be done. These experiments culminated about a year and a

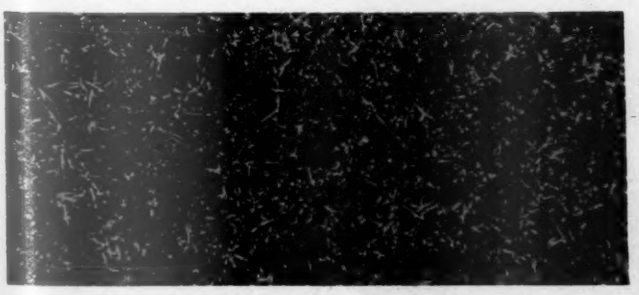


Fig. 2—Babbitt of same composition as Fig. 1 but cast by mandrel process

half ago in a centrifugal method of relining that has given extremely satisfactory results. A description of the process may be of interest to those faced with a similar problem as the principles can be applied to other bearings.

The centrifugal process of casting babbitt is not new, having been used by engine builders for some time. However, no instance of it having been used in relining bearings has come to the attention of the author. Centrifugal casting offers two advantages: (1) it is a comparatively simple process, and (2) it produces a fine-grained, dense metal possessing good wear resistance. Fig. 1 shows the structure of centrifugally cast babbitt at 100 diameters, while Fig. 2 shows the same metal cast from the same temperature against a mandrel by the old method. It will be seen that in Fig. 1 the white crystals are more numerous and smaller than in Fig. 2. These crystals are hard particles that resist wear and insure long life. The small size and good distribution of these hard crystals produces excellent properties in the metal.

Centrifugal casting is ordinarily applied only to cylindrical or essentially cylindrical objects. In the case of the bearings involved here the problem was complicated

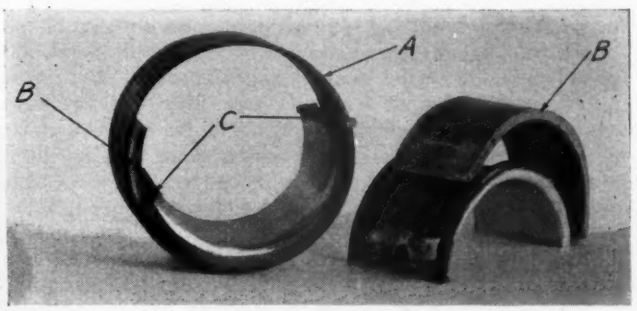


Fig. 3—Assembly of bearing halves

by having the cylinder in two parts. It was necessary to join them together in order to cast the babbitt into them. The two halves could not be simply placed together as they do not form a cylinder when this is done on account of the metal that has been cut out to allow for shims. A fixture to hold the two halves of the bearing together, was therefore necessary. Such a fixture was designed and built by the shops. It is shown in Fig. 3. It consists of three pieces. *A* is a solid steel shell, tapered slightly inside, into which the two halves of the bearing are placed. *B* and *B* are two steel blocks to fill the space between the bronze shells and the steel band *A*. They are tapered on the outside to fit the taper of *A*, while on the inside they have the same radius as the back of the bronze shells. They serve to wedge the two halves of the bearing tightly into the steel band. Narrow strips of wood *C* separate the ends of the bearing halves from each other. They are driven in tightly to assist in holding the parts firmly in place in the steel shell and also to close the gap that would otherwise exist between the ends of the bronze backs. These pieces of wood are shellacked thoroughly a day or two before they are to be used.

Assembling the various parts in the fixture produces the cylindrical shape that is necessary for this process of relining bearings. The completed assembly is handled as a unit during tinning and lining. Several of these fixtures are used, all of them being set up with the bronze backs before any tinning is done. When the bearings

* Chief Chemist, C. M. St. P. & P.

Fig. 4—Fixture for centrifugal casting of connecting-rod bearings

have all been tinned and babbitted they are removed from the fixtures which are then ready for more bearings.

A 1½-hp. three-phase 60-cycle motor, which runs at about 860 r.p.m., when loaded, is used to spin the bearings. A steel drum is mounted directly on one end of the armature shaft to receive the fixture described above, the inside diameter of the drum being just large enough to accommodate it. Fig. 4 gives a good idea of the general arrangement of the various parts. The front of the drum is closed with a screw cap in which there is a hole for pouring the babbitt. A coarse thread is cut in the cap and on the outside of the drum to facilitate rapid tightening.

Once the bearing has been tinned no time must be lost in transferring it to the drum and setting it to spinning or there is danger of the solder freezing before the babbitt can be poured. If this happens the adherence of the babbitt to the bronze is certain to be poor and the bearing will be unsatisfactory. Hence every precaution has been taken to make it possible to carry out quickly all operations subsequent to tinning.

The back wall of the drum serves as a dam for the babbitt on that end while the screw cap closes the other end. Card board washers are used at each end of the bearing to prevent any babbitt from flowing out through any small irregularities and to prevent it sticking to the housing. If this were not done it would be difficult to remove the bearings from the housing after the babbitt had set. When the molten babbitt, at the proper temperature, is poured in it is distributed evenly over the surface of the bearings by centrifugal force.

Preparation of Shells

Proper preparation of the bronze shells prior to soldering was found to be the most important step of the entire operation. Unless the backs are properly cleaned the solder will not adhere as it should and hence the babbitt will not be securely anchored. Early failure of such a bearing can be expected. Several methods of cleaning the old bearings were tried. Sand-blasting and grinding were unsatisfactory. This was probably due to particles being forced into the pores of the bronze with such force that they were not easily removed subsequently.

Machining was satisfactory for cleaning but had the disadvantage that each time a shell was cleaned the thickness of the bronze back was decreased even though only a light cut was taken. Also the thickness of babbitt left after machining to proper size was increased. Neither of these results is desirable. Adequate thickness of the back is necessary for mechanical strength or the bronze is likely to break in service due to the heavy loads. A thick layer of babbitt is undesirable as it is more easily squashed out when thick than when it is kept down to a minimum thickness. Many automotive bearings have babbitt linings only $\frac{1}{32}$ in. thick. The Milwaukee Road does not attempt to work to such low limits but an effort is made to keep the babbitt as thin as is practical for the conditions. Most of the linings are between $\frac{1}{16}$ in. and $\frac{1}{8}$ in. thick.

Fig. 5—Pouring babbitt into the fixture

Hand scraping of the bearings was finally decided upon as the most satisfactory method of preparing the backs for relining. The old babbitt is melted off in a bath of molten scrap babbitt care being taken to shake off all the babbitt possible. When the back is cold the surface is scraped just enough to uncover the bronze. In this way no appreciable metal is removed from the back itself yet a good clean surface is obtained. It is good practice not to do any scraping until just before the bearings are to be relined. If the back stands around the shop after being scraped it becomes dirty again and is difficult to tin properly. Unnecessary handling, especially with greasy hands or gloves, should be avoided or poor adherence is likely to be the result. The newly scraped surface tins without difficulty while dirty bearings are more difficult to tin and may later fail in service even though they appear to tin properly.

The matter of properly preparing the bearings for relining requires and deserves some thought as well as care in the operation. The success or failure of the whole job lies in this step whether the bearings are to be spun in or cast by the usual mandrel method. It may appear that hand scraping is too costly but unless some other satisfactory method is found which is faster and cheaper, the hand method will still be the most economical in the long run. Any method that produces bearings which will not stand up well in service is costly. Delays to trains due to engine failures must be prevented so far as is humanly possible.

Relining of bearings is ordinarily an intermittent job and except in cases of emergency, babbitting is not done until enough bearings are on hand for a days work. The bearings, prepared by scraping as described above and assembled in the fixture, are given a thorough rinse in a hot alkaline cleaner, and then in hot water. This removes any oil and leaves the metal in good condition for fluxing and tinning. If the rinse water is boiling the assembly will dry quickly and no water will be left to cause splashing when the fixture is immersed in the solder. The bearing surface is brushed over with concentrated muriatic acid as a flux and the unit placed in a bath of 50-50 solder maintained at a temperature of 650 deg. F.

The unit is kept in the solder until it reaches the temperature of the bath. Prolonged immersion is avoided because the solder will dissolve the lead in the bronze making the backs brittle and weak. The surplus solder is quickly brushed off the outside with a fiber brush and the fixture inserted into the drum on the motor.

After tightening the face plate the motor is started. Enough babbitt is dipped from the babbitt pot, maintained at 800 deg. F., to fill the bearing. This is poured through the hole in the plate, a hinged trough being used to guide it, see Fig. 5. After spinning about two minutes the babbitt has solidified and the motor is stopped. The unit is then removed. The lined bearings are knocked out and the fixtures used again immediately if sufficient bearings are at hand, as is usually the case.

In the year and a half that this process has been regularly used not one of the bearings has failed so far as is known. None have yet been returned for relining, each one has been marked so that they may be recognized when they do come back. Recently a bearing was inspected after it had been in service more than nine months; (the occasion for this was the failure of a connecting rod) none of the shims had been removed after this period of service and, in spite of the fact that the rod had broken, the bearing was in such good condition that it was returned to service.

The tin-base babbitt used in lining these bearings has the following approximate composition: Tin 89 per cent, copper 3.5 per cent, antimony 7.5 per cent, lead and arsenic, a trace. The Brinell hardness at room temperature is about 25 (10 m.m. ball 500 kg. pressure). It is poured at 800 deg. F. whether it is to be cast by the centrifugal or mandrel process. The same metal is used in lining the main bearings of these engines. Some of the mains are lined centrifugally but not all as the necessary fixtures have not been made for them. Further they give very little trouble. This is good evidence that the chief cause of the trouble in the connecting-rod bearings is the severity of service. Tinning practices that are satisfactory for bearings subjected to normal stresses are not good enough for highly stressed bearings.

Fusion Welding On Boilers and Tanks*

Two committee reports on fusion welding as applied to locomotive boilers and tenders were submitted at the recent convention of the Master Boiler Makers' Association. The first outlined the development of the art up to the present time when practically all fireboxes are built up with fusion-welded butt seams, welding at firedoor holes is almost universal, tubes and flues are generally welded, and the process is being steadily extended. The second report dealt more particularly with details of the application of welding to locomotive boilers and tanks. Brief abstracts follow.

The joining of sheets in locomotive fireboxes by fusion welding has been adopted on practically all railroads. The process most commonly used is the electric arc, while oxy-acetylene is also extensively used. The butt

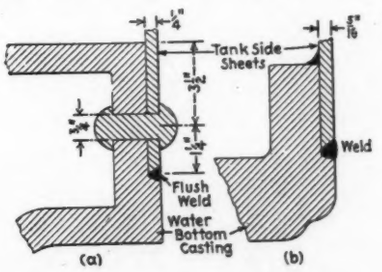


Fig. 1

Welding tender side sheets to water-bottom underframe

weld, with sheets beveled on the fire side, is the recognized and preferred type of joint used. Wherever it is possible, the weld is reinforced on the opposite side of the bevel. In preparing firebox sheets for welding an opening of from $\frac{1}{8}$ to $\frac{3}{16}$ in. should be allowed between the sheets to obtain the full penetration of the weld. Where the shielded arc electrodes are used, closer fitting is necessary and an opening of $\frac{1}{16}$ in. between sheets is sufficient. The bevel on each sheet should not be less than 30 deg.

After clamping the sheets in place they should be tacked at sufficiently close intervals to hold them properly in place while welding. All necessary tacking should be done before the welding is started, to prevent the sheets from being drawn out of line and also to hold a uniform opening between the sheets to secure proper penetration.

In welding locomotive oil tanks and tenders to replace

* Abstracted from two committee reports submitted at the September, 1935, meeting of the Master Boiler Makers' Association. Complete reports with discussion are given in the proceedings published in the October, 1935, issue of the Boiler Maker and Plate Fabricator.

the former practice of riveting, some railroads now use the all-welded type of construction and, up to this time, it has proved satisfactory. Other railroads have resorted to a combination of riveted and welded construction which has also given satisfactory results.

Where cast-steel tender frames of the water-bottom type are used, some railroads are welding the outside plates to the cast-steel underframe, the sheets being welded at the bottom edge to the frame on the outside

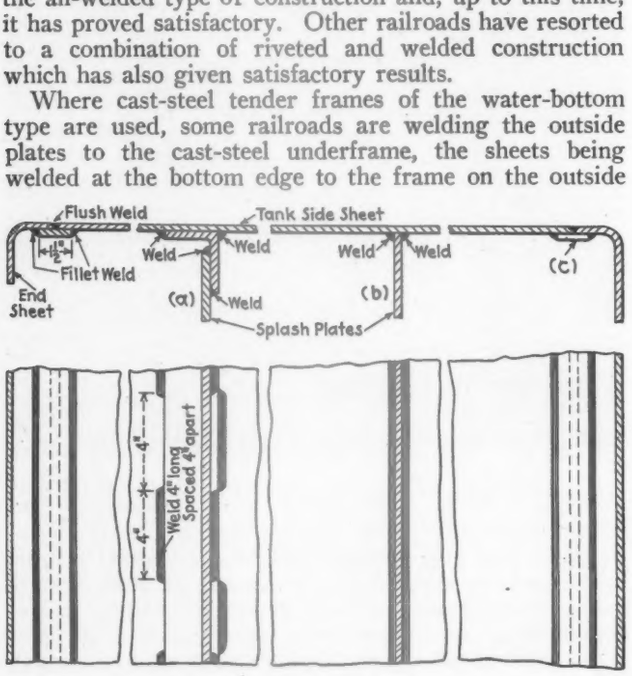


Fig. 2

Details of tender-tank welds

where it laps over the casting. They are also fillet welded to the casting on the inside, thereby eliminating the possibility of water getting between the sheets and casting and starting corrosion, as may be the case if the weld is not made on the water side. This construction also acts as a stiffener to support the sides. See Fig. 1 (b).

Where the combination of welded and riveted construction is used, this same type of welded joint is made,

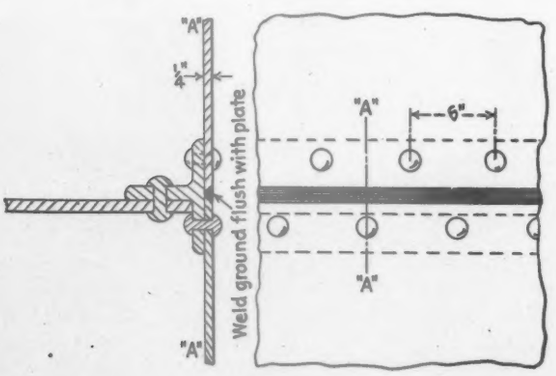


Fig. 3

Welding used in replacing tank side sheets

except that the filet welding on the water side of the tank is omitted and the rivets are spaced above the bottom horizontal wild. See Fig. 1 (a).

Stiffening angles, cross-braces and splash plates are applied in the all-welded construction, as outlined in Fig. 2 (a) and (b), where rivets are entirely eliminated. When judging the stiffening effect of the construction as outlined in Fig. 2 (a) it occurs to your committee that this design is most desirable. There are features in favor of the construction shown in Fig. 2 (b), such as lightness of construction and lower cost of application, which may be preferred in the construction of lighter

Fig. 4

Welded rib for protecting staybolts

tanks. However, sufficient comparative service has not been rendered for your committee to be justified in making any recommendations as to which type of construction could be recommended as a standard practice.

Fig. 2 (c) shows the type of vertical seam being used in some designs of water-tank cisterns. In this design the welt strap is placed on the water side of the plate, which has a tendency to produce a stiffening effect on the flat vertical sides of the tank plate.

Where repairs are made to the present riveted type of tank construction, there are times when it is necessary to remove large plates, especially in the sides of tank cisterns, in order to repair the defect and maintain their uniform appearance. Before fusion welding was developed large sections were usually riveted in place,

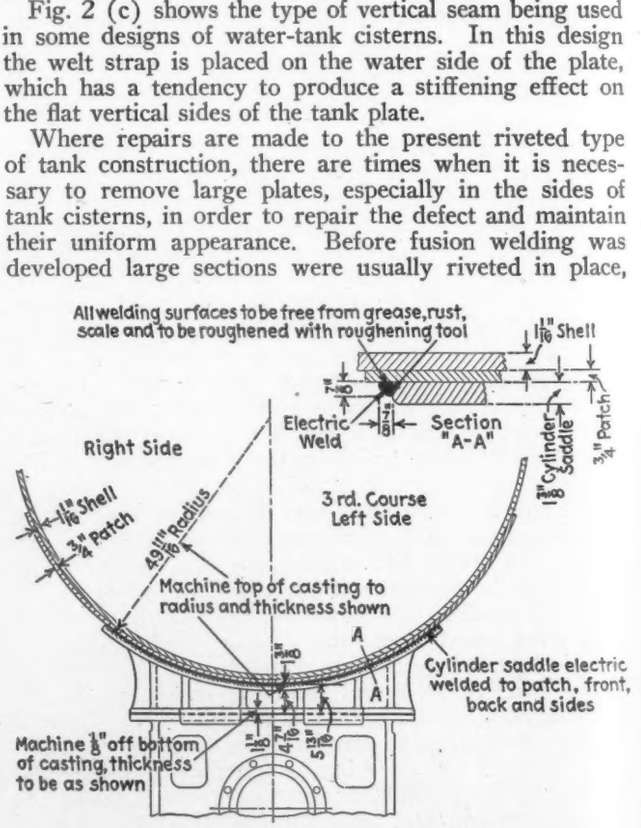

All welding surfaces to be free from grease, rust, scale and to be roughened with roughening tool
1" Shell
Electric Weld
Section "A-A"
Cylinder Saddle
3/4" Patch
Right Side
1" Shell
3/4" Patch
49 1/16" Radius
3rd. Course Left Side
Machine top of casting to radius and thickness shown
A
A
Cylinder saddle electric welded to patch, front, back and sides
Machine 1/8" off bottom of casting, thickness to be as shown

Fig. 5

Welded saddle liner on a single-expansion locomotive

the cost of which was high. The cost of this class of repair has been greatly reduced because smaller sheets are now welded between the horizontal riveted seams of angle or tee braces, as outlined in Fig. 3, following the center line of braces and not changing the appearance of the outer portion of the tank where the section is applied. Some railroads now consider it a standard practice to insert the lower one-third section in this manner as it becomes necessary.

Fig. 4 shows a fusion welded rib which is applied to the fire side of firebox plates where cinder cutting is causing the heads of staybolts to be cut away. These

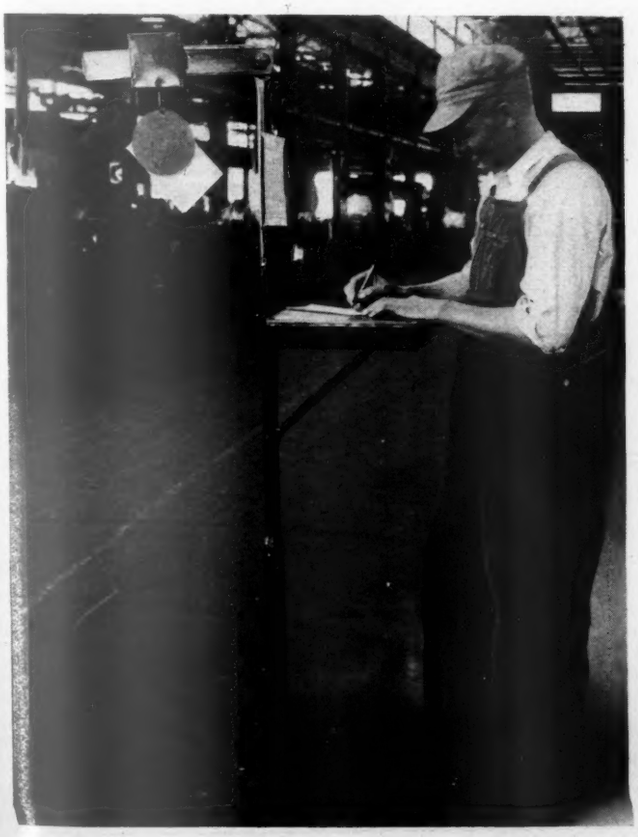
ribs are welded in place while the water is in the boiler and have the effect of minimizing the cinder cutting action on the fire ends of the bolts.

One railroad has a single-expansion articulated type locomotive in service with the No. 2 cylinder saddle and the boiler-bearer castings electrically welded to a liner, Fig. 5, which is riveted to the barrel of the boiler especially for this purpose. This practice eliminates the use of a cylinder saddle and boiler bearer bolts and holes in the barrel of the boiler. Freedom of leakage from these sources is of material advantage. This locomotive has been in service for almost two years. The illustration shows the manner in which the cylinder saddle and bearers are prepared and the method used for welding.

Shop-Material Order and Delivery Stand

The illustration shows a comparatively new type of shop-material order and delivery stand which is being successfully used at the West Burlington (Iowa) shops of the Chicago, Burlington & Quincy. Stands of this type are located throughout the shop for use by gang foremen, store department redcaps or material supply boys and shop tractor operators, who handle all material to and from the shop as well as the inter-shop deliveries.

These stands are 70 in. in height with a steel plate base ½ in. by 12 in. by 12 in. A piece of 2 in. scrap flue, 22 in. in height, is fastened to the base plate, and welded within this flue is a 1¼ in. pipe extending to the top of the stand. To this pipe, approximately half way from the floor, is fastened the desk which is 14 in. by 12 in. by 2½ in., made of No. 16 jacket iron. At the top of the pipe is an arm 13 in. by 3 in. bent to form a guide. A 3-in. plate moves in this guide.



Shop-material order and delivery stand at West Burlington shops

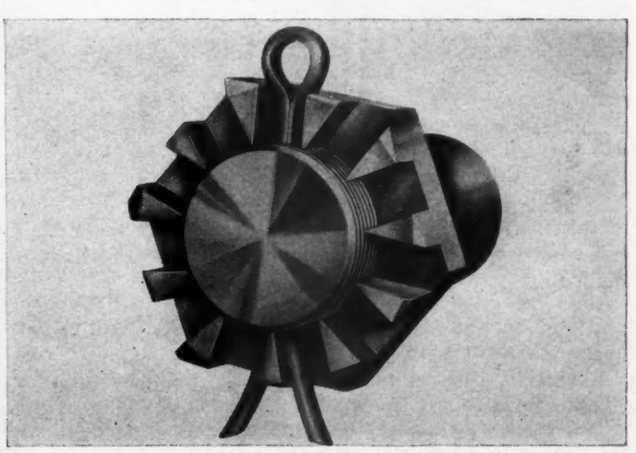
This movable plate is painted on the outside with a 2-in. red and yellow stripe, which permits two different signals; namely, when the entire plate is visible, showing both the red and yellow stripes, the foreman has placed an order on the hook; a redcap picks up the order and pushes the plate in half way so that only the red portion is visible. The plate is entirely pushed in when the order has been filled. A yellow disc 6 in. in diameter is hung on the hook when the foreman desires the service of a shop tractor.

The tin box fastened on the stand serves as a writing table as well as a holder for requisition pads. This eliminates the necessity of gang foremen carrying these requisition pads, the stand being centrally located in each department and immediately accessible.

Orders are hung on the hook at the top of the stand, being gathered as delivery men pass the various stations. All orders are marked to designate the stations to which material should be delivered. A holder on this rack serves in posting the weekly engine report showing the status of all engines in the shop.

Slotted Nut with Closer Adjustments

An improved nut of the Cooke type which offers from 10 to 22 adjustments per turn depending on size, instead of the usual six per turn, is now being marketed by the Blatchford Corporation, 80 E. Jackson Boulevard, Chicago, Ill. On this nut, which is known as the Cooke micro-slotted nut with closer adjustments, the micromatic adjustment is obtained by locating the keying wedges off center from one another so that two keying positions are possible for each slot. At the keying position a wedge centers the hole and if hole



Cooke micro-slotted nut with closer adjustments

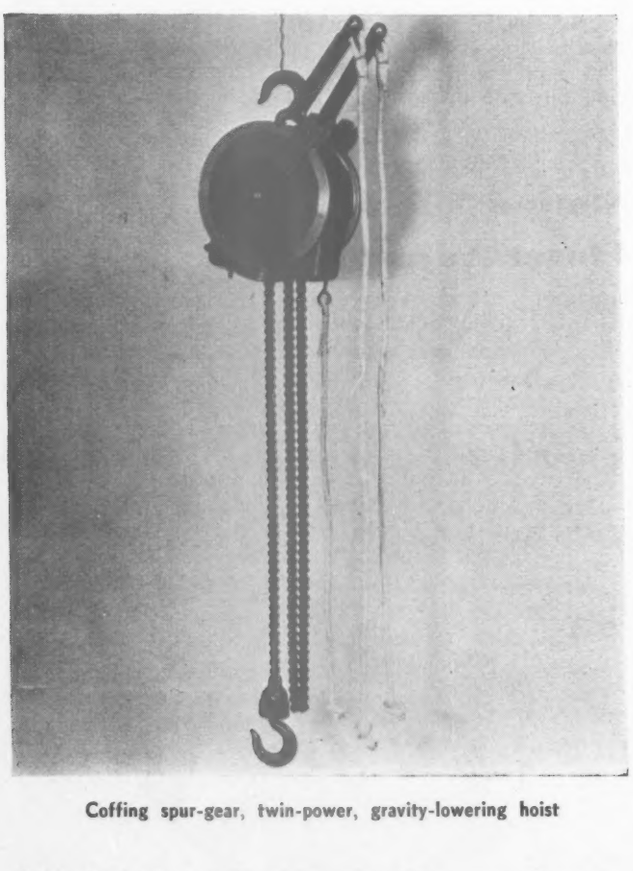
and wedge are not in keying position at the first trial, a slight tightening will bring a wedge into position at one end or the other of the hole, so that the key can be inserted from either end. Because of this closer adjustment—.008 in. to .013 in. depending on size—there never is an occasion for backing off the nut to get a keying position or for tightening with shims.

The key is set by simply tapping it in with a hammer, no pliers being needed. The key spreads automatically, curving outward and filling the space between the wedge

and sides of the hole, firmly locking the bolt, nut, and key. A special key is supplied with each nut. The end of the key is trimmed off to an internal V-shape so that it spreads readily around the keying wedge on the nut, without catching on the wedge. The smoothly curved shape of the key when set gives this nut a neat, workmanlike appearance when installed.

Coffing Gravity Lowering Hoist

The Coffing Hoist Company, Danville, Ill., has recently perfected a type of hoist known as the Challenger, said to be the only spur-gear, twin-power, gravity-lowering chain hoist on the market. As shown in the illustration,



Coffing spur-gear, twin-power, gravity-lowering hoist

this hoist is designed to be operated by rope pull on two levers which have a friction grip on the faces of two disk wheels, thus eliminating entirely the necessity for a hand-chain to lift the load.

The load is lowered by gravity to any position desired, the speed being entirely controlled by a simple governor arrangement. When there is no weight on the hoist, the slack in the load chain can be taken up by pulling on the loose end of the chain, or the chain can be pulled out free for quick adjustment by simply releasing the clutch, which also is rope operated.

The Challenger is said to be fast, efficient and durable in operation. It is provided in four capacities, namely: ¼, ½, 1 and 2 tons. It is fully ball-bearing equipped and designed to operate with safety under 100 per cent overload. In railway shop service, this type of hoist is a great time and labor saver when used for handling heavy parts, such as crossheads, pistons, rods, etc., during the various machining and assembly operations. The gravity-lowering design and free chain for quick adjustment are particularly valuable features.

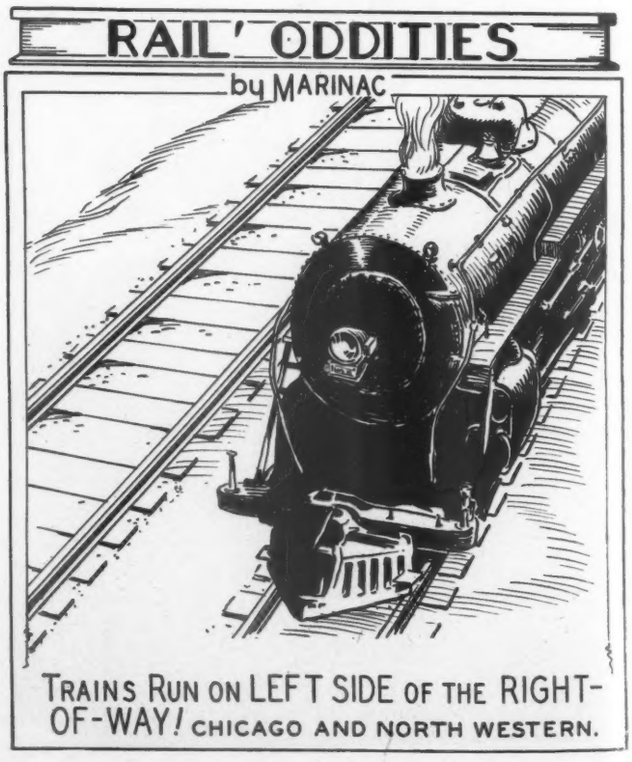
Collapsible Hand Tap

A hand sizing tap of the collapsible type designed primarily to take the place of the solid adjustable taps ordinarily used has been added to the line of machine collapsible taps manufactured by the Landis Machine Company, Waynesboro, Pa. These taps offer the advantage of instant withdrawal from the work without requiring to be backed out. They also eliminate the tearing of threads, frequently caused by backing out a solid tap, as well as undue wear of the chasers by having the radial clearance worn off in the backing-out operation. Tapping time is, of course, saved, thereby increasing production.

A small handle or trigger is located on the side of the tap body for unlatching the tap and collapsing the chasers by pressing back on the handle. The chasers are reset by pressing against a plunger extending slightly beyond the rear of the tap shank. The tap shank is provided with a square end to fit a tap wrench. Any length of shank or tap can be supplied.

The top is provided with a diametrical adjustment of approximately $\frac{1}{32}$ in. both over and under the nominal chaser size, a total of $\frac{1}{16}$ in. The adjusting screw is located in the front end of the tap and is of the ratchet type, making it self-locking to maintain size. A turn of one notch to the adjusting screw gives a diametrical movement of the chasers amounting to .001 in., an important feature for hand sizing work. These taps can be furnished in all sizes from 1⅜ in. to 12 in., inclusive.

* * *



For explanation see page 224

Among the Clubs and Associations

SOUTHERN AND SOUTHWESTERN RAILWAY CLUB.—Frank M. Robbins, president, Ross-Meehan Foundries, Chattanooga, Tenn., will present a paper on malleable and steel castings at the May 21 meeting of the Southern and Southwestern Railway Club which will be held at 10 a.m. at the Ansley Hotel, Atlanta, Ga.

WESTERN RAILWAY CLUB. — C. N. Wright of Scottsbuff, Neb., will discuss "The Railroads—Their Condition and Needs" at the annual meeting of the Western Railway Club to be held at 8:30 p.m. on May 25 at the Sherman Hotel, Chicago. A reception at 5 p.m. and dinner at 7 p.m. will precede the meeting.

PACIFIC RAILWAY CLUB.—"Fuel Conservation and What It Means to the Railroads" will be the topic discussed by Ralph S. Twogood of the Southern Pacific and Guy M. Bean of the American Arch Company before the May 14 meeting of the Pacific Railway Club which will be held at 7:30 p.m. at the Transportation Club, Palace Hotel, San Francisco, Calif.

A. S. M. E. Spring Meeting

THE semi-annual meeting of the American Society of Mechanical Engineers will be held at Dallas, Tex., June 15 to 22, inclusive. This is during the early part of the Texas Centennial Exposition. While the headquarters for the meeting will be at the Hotel Adolphus, most of the technical sessions will be held in the Power Building and the Telephone Building, both of which are within a block of the hotel. The program now includes the following technical papers:

WEDNESDAY, JUNE 17

Railroad Locomotive Session

9:30 a.m.

Equipment Problems in Handling Oil as a Locomotive Fuel, by Guy Bean.
Railroad Lubricants, B. F. Hunter.
Production of Locomotive Fuel Oil, M. C. VanGundy.

3:15 p.m.

Transportation Session

Diesel Electric Locomotives for Switching and Transfer Service, R. D. Krape.
Mass Transportation for Cities, J. C. Thirwall.
Fuels for Today's and Tomorrow's Engines, Earl Bartholomew and C. D. Howley.

Machine Shop Session

The Use of the X-ray Testing of Welded Vessels, H. R. Isenburger.
The Spraying of Molten Metal, L. E. Kunkler.

THURSDAY, JUNE 18

9:30 a.m.

Air Conditioning Session

Sensible and Latent Heat Control for Air Conditioning, F. W. Rabe, Jr.

Educational and Training Session

Vocational Training in the Southwest, A. W. Breeland.

2:00 p.m.

Diesel Session

Fuel Injection Spark Ignition Oil Engines, N. Fodor.
Diesel Fuels, T. B. Rendel

Annual Meetings of Mechanical Associations

THE annual meetings of the following associations are scheduled to be held at the Hotel Sherman, Chicago, on September 15 to 18 as follows:

SEPTEMBER 15 AND 16

Traveling Engineers' Association
Air Brake Association
International Railway General Foremen's Association
Car Department Officers' Association

SEPTEMBER 17 AND 18

International Railway Fuel Association
International Railway Master Blacksmiths' Association
American Railway Tool Foremen's Association
Master Boiler Makers' Association

DIRECTORY

The following list gives names of secretaries, dates of next regular meetings, and places of meetings of mechanical associations and railroad clubs:

AIR-BRAKE ASSOCIATION.—T. L. Burton, care of Westinghouse Air Brake Company, 3400 Empire State Building, New York. Annual meeting, September 15 and 16, Hotel Sherman, Chicago.

ALLIED RAILWAY SUPPLY ASSOCIATION.—F. W. Venton, Crane Company, Chicago.

AMERICAN RAILWAY TOOL FOREMEN'S ASSOCIATION.—G. G. Macina, 11402 Calumet avenue, Chicago. Annual meeting, September 17 and 18, Hotel Sherman, Chicago.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—C. E. Davies, 29 West Thirty-ninth street, New York. Semi-annual meeting, June 15-22, Dallas, Tex.

RAILROAD DIVISION.—Marion B. Richardson, 192 East Cedar street, Livingston, N. J.

MACHINE SHOP PRACTICE DIVISION.—G. F. Nordenholt, 330 West Forty-second street, New York.

MATERIALS HANDLING DIVISION. — F. J. Shepard, Jr., Lewis-Shepard Co., Watertown Station, Boston, Mass.

OIL AND GAS POWER DIVISION. — M. J. Reed, 2 West Forty-fifth street, New York.

FUELS DIVISION.—W. G. Christy, Department of Health Regulation, Court House, Jersey City, N. J.

ASSOCIATION OF AMERICAN RAILROADS.—J. M. Symes, vice-president operations and maintenance department, Transportation Building, Washington, D. C.

DIVISION I. — OPERATING. — SAFETY SECTION.—J. C. Caviston, 30 Vesey street, New York.

DIVISION V.—MECHANICAL.—V. R. Hawthorne, 59 East Van Buren street, Chicago. Meeting, June 25 and 26.

COMMITTEE ON RESEARCH.—E. B. Hall, chairman, care of Chicago & North Western, Chicago.

DIVISION VI.—PURCHASES AND STORES.—W. J. Farrell, 30 Vesey street, New York.

DIVISION VIII.—MOTOR TRANSPORT.—CAR SERVICE DIVISION.—C. A. Buch, Transportation Building, Washington, D. C.

ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.—Jos. A. Andreucetti, C. & N. W., 1519 Daily News Building, 400 West Madison street, Chicago, Ill.

CANADIAN RAILWAY CLUB.—C. R. Crook, 2271 Wilson avenue, Montreal, Que. Regular meetings, second Monday of each month, except in June, July and August, at Windsor Hotel, Montreal, Que.

CAR DEPARTMENT OFFICERS' ASSOCIATION.—A. S. Sternberg, master car builder, Belt Railway of Chicago, 7926 South Morgan street, Chicago. Annual meeting, September 15 and 16, Hotel Sherman, Chicago.

CAR FOREMEN'S ASSOCIATION OF CHICAGO.—G. K. Oliver, 2514 West Fifty-fifth street, Chicago. Regular meetings, second Monday in each month, except June, July and August, La Salle Hotel, Chicago, Ill.

CAR FOREMEN'S ASSOCIATION OF OMAHA, COUNCIL BLUFFS AND SOUTH OMAHA INTERCHANGE.—H. E. Moran, Chicago Great Western, Council Bluffs, Ia. Regular meetings, second Thursday of each month at 1:15 p. m. at Union Pacific shops, Council Bluffs.

CENTRAL RAILWAY CLUB OF BUFFALO.—Mrs. M. D. Reed, Room 1817, Hotel Statler, Buffalo, N. Y. Regular meetings, second Thursday each month, except June, July and August, at Hotel Statler, Buffalo.

EASTERN CAR FOREMEN'S ASSOCIATION. — E. L. Brown, care of the Baltimore & Ohio, St. George, Staten Island, N. Y. Regular meetings, fourth Friday of each month, except June, July, August and September.

INDIANAPOLIS CAR INSPECTION ASSOCIATION.—R. A. Singleton, 822 Big Four Building, Indianapolis, Ind. Regular meetings, first Monday of each month, except July, August and September, at Hotel Severin, Indianapolis, at 7 p. m.

INTERNATIONAL RAILWAY FUEL ASSOCIATION. — T. D. Smith, 1660 Old Colony Building, Chicago. Annual meeting, September 17 and 18, Hotel Sherman, Chicago.

INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION.—William Hall, 1061 West Wabasha street, Winona, Minn. Annual meeting, September 15 and 16, Hotel Sherman, Chicago.

INTERNATIONAL RAILWAY MASTER BLACKSMITHS' ASSOCIATION.—W. J. Mayer, Michigan Central, 2347 Clark avenue, Detroit, Mich. Annual meeting, September 17 and 18, Hotel Sherman, Chicago.

MASTER BOILER MAKERS' ASSOCIATION. — A. F. Stiglmeier, secretary, 29 Parkwood street, Albany, N. Y. Annual meeting, September 17 and 18, Hotel Sherman, Chicago.

NEW ENGLAND RAILROAD CLUB.—W. E. Cade, Jr., 683 Atlantic avenue, Boston, Mass. Regular meetings, second Tuesday in each month, excepting June, July, August and September, at Copley-Plaza Hotel, Boston.

NEW YORK RAILROAD CLUB.—D. W. Pye, Room 527, 30 Church street, New York. Meetings, third Friday in each month, except June, July and August, at 29 West Thirty-ninth street, New York.

NORTHWEST CAR MEN'S ASSOCIATION. — E. N. Myers, chief interchange inspector, Minnesota Transfer Railway, St. Paul, Minn. Meetings, first Monday each month, except June, July and August, at Minnesota Transfer Y. M. C. A. Gymnasium Building, St. Paul.

PACIFIC RAILWAY CLUB.—William S. Wollner, P. O. Box 3275, San Francisco, Cal. Regular meetings, second Thursday of each month in San Francisco and Oakland, Cal., alternately—June in Los Angeles and October in Sacramento.

RAILWAY CLUB OF GREENVILLE. — J. Howard Waite, 43 Chambers avenue, Greenville, Pa. Regular meetings, third Thursday in month, except June, July and August.

RAILWAY CLUB OF PITTSBURGH.—J. D. Conway, 1941 Oliver Building, Pittsburgh, Pa. Regular meetings, fourth Thursday in month, except June, July and August, Fort Pitt Hotel, Pittsburgh, Pa.

RAILWAY FIRE PROTECTION ASSOCIATION.—R. R. Hackett, Baltimore & Ohio, Baltimore, Md.

RAILWAY SUPPLY MANUFACTURERS' ASSOCIATION.—J. D. Conway, 1941 Oliver Building, Pittsburgh, Pa. Meets with Mechanical Division and Purchases and Stores Division, Association of American Railroads.

SOUTHERN AND SOUTHWESTERN RAILWAY CLUB.—A. T. Miller, P. O. Box 1205, Atlanta, Ga. Regular meetings, third Thursday in January, March, May, July and September. Annual meeting, third Thursday in November, Ansley Hotel, Atlanta, Ga.

TORONTO RAILWAY CLUB.—R. H. Burgess, Box 8, Terminal A, Toronto, Ont. Meetings, fourth Monday of each month, except June, July and August.

TRAVELING ENGINEERS' ASSOCIATION. — A. T. Pfeiffer (president), New York Central, Syracuse, N. Y. Annual meeting, September 15 and 16, Hotel Sherman, Chicago.

WESTERN RAILWAY CLUB.—C. L. Emerson, executive secretary, 822 Straus Building, Chicago. Regular meetings, third Monday in each month, except June, July, August and September.

NEWS

John M. Lessells Associate Professor at M. I. T.

JOHN M. LESSELLS, until recently consulting engineer of the Westinghouse Electric & Manufacturing Company, has been appointed associate professor of mechanical engineering at the Massachusetts Institute of Technology, Cambridge, Mass. Mr. Lessells, who was born in Scotland, for 11 years was manager of the applied mechanics division of the Westinghouse Electric & Manufacturing Company at Pittsburgh and then engineering manager of the turbine and Diesel department at Philadelphia. He is editor of the Journal of Applied Mechanics published by the American Society of Mechanical Engineers.

Sante Fe Will Cut California Time and Add Two Trains on May 10

THE Atchison, Topeka & Santa Fe, on May 10, will place the Scout on a 60-hr. 55-min. schedule between Chicago and Los Angeles, Cal., and will reduce the schedule of its Chief 2¼ hr. westbound and 4 hr. 35 min. eastbound. On May 12, it will place in service the Super Chief, a train of standard Pullman equipment drawn by a 3,600-hp. locomotive, on a 39¾-hr. schedule between Chicago and Los Angeles. The Super Chief will leave Chicago at 7:15 p.m. on each Tuesday and will arrive in Los Angeles at 9 a.m. each Thursday, while eastbound it will leave Los Angeles at 8 p.m. each Friday and will arrive in Chicago at 1:45 p.m. each Sunday. The 39¾-hr. schedule of the Super Chief will be 14 hr. faster than the present fastest service between Chicago and California. Later in the year, the cars of this train will be replaced by light-weight stainless steel cars recently ordered from the Budd Manufacturing Company. The extra fare on the Super Chief will be $10.

With the inauguration of this train, the Chief, which made its first run on November 14, 1926, will operate on a schedule of 51 hr. 29 min. westbound instead of 53¾ hr. and 54 hr. 25 min. eastbound instead of 59 hr. It will leave Chicago at 12:01 p.m. instead of 11:15 a.m. and will arrive in Los Angeles at 1:30 p.m. the third day instead of 3 p.m., while returning, it will leave Los Angeles at 9:30 a.m. instead of 11:45 p.m. and will arrive in Chicago at 1:55 p.m. the third day instead of 8:45 a.m. the fourth day.

The Scout, which is designed primarily for the convenience of coach and tourist travel, will leave Chicago at 8:45 p.m. and arrive in Los Angeles at 7:40 a.m. No major changes are contemplated in the daily schedules of either the California Limited or the Grand Canyon Limited. The Super Chief, the Chief, the California Limited and the Grand Canyon Limited will all be completely air-conditioned.

Electro-Motive Diesel Plant Now in Production

THE practice period for breaking in machinery and workmen at the new plant of the Electro-Motive Corporation, LaGrange, Ill., has been completed and work is now in progress on orders for Diesel locomotives, representing an outlay of about $3,500,000. Construction of this plant, which occupies a 74-acre site on the Indiana Harbor Belt, was started in March, 1935, and completed in about seven months' time by the Austin Company, Cleveland, Ohio.

General view of the erecting shop of the Electro-Motive Corporation plant at LaGrange, Ill.

"The Making of Alloy Steel"

THE Bethlehem Steel Company has completed a new talking motion picture entitled "The Making of Alloy Steel." All of the various processes in the making of alloy steel, beginning with the charging of the open-hearth furnace through to the loading of finished bars on freight cars, are shown in this picture, also the checking and re-checking operations that are necessary in order to assure that the steel will be made according to specifications.

The explanatory lecture on the sound track follows the various processes of manufacture and explains the results obtained in the case of many of the operations and treatments.

The picture is technical throughout and takes 45 min. to show.

"City of Los Angeles" Completed

THE streamline train "City of Los Angeles" has been completed by Pullman-Standard Car Manufacturing Company and will be delivered to the Chicago & North Western-Union Pacific in a few days. After exhibitions at Chicago, Omaha, Neb., Columbus, Grand Island, Kearney, Cheyenne, Wyo., and Laramie, Ogden, Utah, and Salt Lake City and Los Angeles, Cal., Pasadena and Glendale, the 11-car train, propelled by a 2100-hp. Diesel-electric power plant, will be placed in service between Chicago and Los Angeles on a schedule of 39¾ hours for the 2298 miles, making the first trip from Los Angeles on May 15.

The streamliner will depart from these terminals each five days. "Sailing" dates from Chicago will be 6:15 p.m. on the second, seventh, twelfth, seventeenth, twenty-second, and twenty-seventh of each month and from Los Angeles at 3:45 p.m. on the fifth, tenth, fifteenth, twentieth, twenty-fifth and last day of the month. It will arrive at Chicago at 9:30 a.m. and Los Angeles at 8 a.m. the second morning. A supplementary fare of $10 between terminals will be made in Pullman cars and $5 in coaches. The nine revenue cars have a capacity for 170 passengers, 84 in the Pullmans and 86 in the coaches.

British Road Designs Car for Fragile Freight

THE Great Western of Great Britain has recently developed a new type of freight car designed to minimize damage in transport of such commodities as eggs, fruit, furniture and other fragile articles. The design of the new car is described in a recent announcement as embodying "simplicity itself," the interior being fitted with a series of partitions which can be

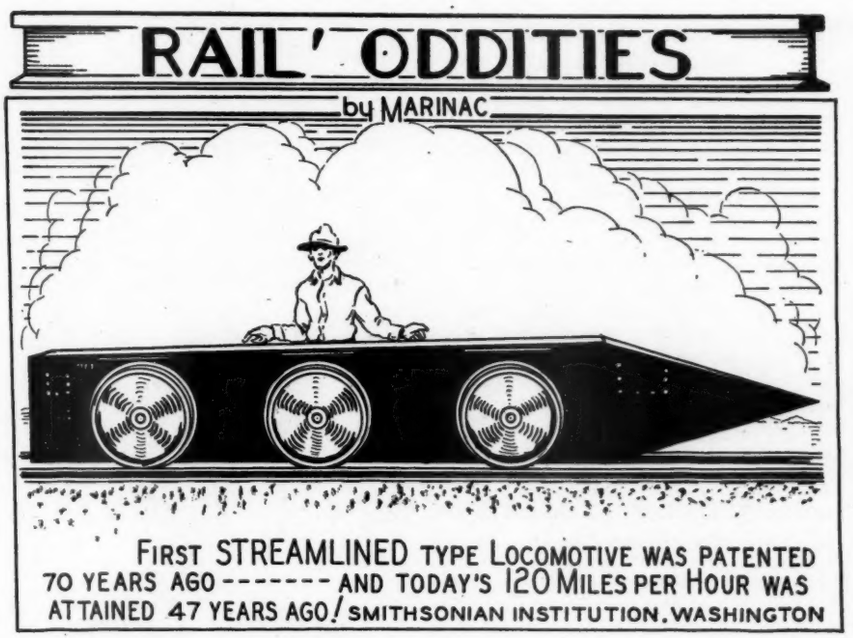
adjusted to hold the stacked commodities in position no matter how small the load may be.

The decision to equip 100 cars was the result of a year's experiment with 15 originally equipped. It is claimed that "this new system is the best so far devised for the protection of traffic in transit."

Report of Bureau of Explosives

W. S. Topping, chief inspector of the "Bureau for the Safe Transportation of Explosives and Other Dangerous Articles," has sent to J. M. Symes, vice-president of the Association of American Railroads, the annual report of the Bureau for the year 1935. The Bureau has now been operating for about 29 years, and the report gives a brief description of its activities. The contrast between the imperfect safety of railroad transportation, prior to 1907, with the constantly improving safety which has been reported by this bureau since then is well known.

The number of routine inspections made by the Bureau in 1935 was 23,909, a slight increase over the preceding year. In connection with rough handling of cars, the Bureau takes cognizance of other freight as well as dangerous articles, and reports that the use of impact recorders in freight cars gives increasing satisfaction. In Chicago and environs, where there is a heavy intra-city interchange of loaded cars, the use of impact recorders has been found economical.


RAIL' ODDITIES
by MARINAC
FIRST STREAMLINED TYPE LOCOMOTIVE WAS PATENTED
70 YEARS AGO ------- AND TODAY'S 120 MILES PER HOUR WAS
ATTAINED 47 YEARS AGO! SMITHSONIAN INSTITUTION. WASHINGTON

For explanation see page 224

New Equipment

Locomotive Orders

Road	No. of locos.	Type of locomotive	Builder
Joplin-Pittsburg	1	Double-unit, 70-ton propane-elec.	Fate-Root-Heath Co.
La Salle & Bureau County	1	Double-unit, 70-ton propane-elec.	Fate-Root-Heath Co.
New York Central	7	Plymouth Diesel-elec. switchers	Electro-Motive Corp.

Locomotive Inquiries

Alton & Southern	1	2-8-2	

Freight-Car Orders

Road	No. of cars	Type of car	Builder
Erie	500	50-ton box	American Car & Foundry Co.
	200	50-ton automobile	Magor Car Corp.
	100	50-ton automobile (with loaders)	Greenville Steel Car Co.
Pacific Fruit Express	500	Refrigerator	General American Car Co.
	500	Refrigerator	American Car & Foundry Co.
	500	Refrigerator	Pacific Car & Foundry Co.
	500	Refrigerator	Pullman-Std. Car Mfg. Co.
	700	Refrigerator	Company shops
Seaboard Air Line	100	70-ton phosphate	Pullman-Std. Car Mfg. Co.
Wheeling & Lake Erie	50	Automobile	Company shops

Freight-Car Inquiries

Chesapeake & Ohio	3,500	50-ton hoppers	
	500	50-ton flat bottom gondolas	
	1,000	50-ton box, steel sheathed, 40 ft. 6 in. long	
	150	50-ton drop-end gondolas, with steel floors	
	100	50-ton drop-end gondolas, with wood floors	
	150	50-ton automobile	
Missouri Pacific	1,500	50-ton box	
	500	55-ton hoppers	
N. Y., C. & St. L.	500	50-ton box	
	200	50-ton gondolas	
	50	70-ton gondolas	
	25	50-ton flat	
	2	100-ton flat	
Pere Marquette	400	50-ton auto-freight, 40 ft. 6 in. long	
	100	50-ton auto-freight, 50 ft. 6 in. long	
Western Pacific	50	Steel underframes	

Passenger-Car Orders

Atchison, Topeka & Santa Fe	1 [1]	8-car streamline train	Edward G. Budd Mfg. Co.
N. Y., N. H. & H.	50 [2]	Light-weight	Pullman-Std. Car Mfg. Co.

Passenger-Car Inquiries

Norfolk Southern	3	Light-weight coaches	
	3	Light-weight pass. and bagg. cars	
	3	Light-weight bagg. and mail cars	

[1] This eight-car, streamline stainless steel train, for delivery within six months, will be placed in service in this company's "Super Chief" on a once-a-week round trip schedule of 39 hrs. 45 min. each way between Chicago and Los Angeles, Cal. Drawn by the company's 3600-hp. Diesel-electric locomotive, the "Super Chief" will go into service early in May on this schedule and, pending delivery of the light-weight equipment, will operate with standard steel equipment. The new streamline train will include a baggage car, a dining car, a cocktail lounge club car, four sleepers and a sleeper observation car, and will weigh about one-half as much as a conventional steel train.

[2] Twenty for main-line service and 30 for suburban service.

A table is given covering 15 years, showing derailments caused by failure of arch-bar trucks, from which it is found that the major portion of the losses in this class was due to the presence of dangerous articles in the cars. This table shows, for the 15 years, 142 tank cars derailed; other cars derailed, 34; losses, tank cars, $1,631,868; other cars, $483,538.

Improvement Programs

In continuance of a program under way, the Grand Trunk Western will rebuild and modernize 600 hopper bottom coal cars and 350 box cars in its shops. Coaches used in the Detroit-Pontiac suburban service are being air-conditioned, while the air-conditioning program extends to parlor and dining cars used in Grand Trunk service. This air conditioning is in addition to the air conditioning of Pullman cars in use on the international runs between Chicago and Detroit, Mich., and Toronto, Ont., and Montreal, Que., and the sleeping cars operating to and from Muskegon, Mich., South Bend, Ind., Lansing, Mich., Flint and other services. The Grand Trunk Western also plans to purchase 100 fifty-foot automobile box cars and 100 fifty-foot gondola cars.

The Chicago, Rock Island & Pacific has given a contract to the American Car & Foundry Company to modernize seven chair cars.

The Wheeling & Lake Erie is building 50 new automobile cars and has work under way on the rehabilitation of disabled cars, in its shop at Toledo, Ohio, where three hundred fifty men are now employed.

The Denver & Rio Grande Western's $2,286,248 improvement program for 1936, authorized by the district court, covers only the first year of a comprehensive program which will require four years for completion. Among the expenditures for this year will be $250,000 for air-conditioning coaches, lounge-observation cars and dining cars which are being built at the Burnham shops.

Plan Drafting of National Smoke Prevention Code

PLANS are being made for the drafting of a national "smoke prevention code" with law-enforcing features at the annual convention of the National Smoke Prevention Association, which is to be held at the Hotel Ansley, Atlanta, Ga., on June 2-5. The code, which is to be drafted by representatives of various interested agencies in co-operation with the association, will be designed to be applicable to cities throughout the country. It is expected that those in attendance at the convention will include municipal officials from practically every large city, railroad officers, hotel managers and other business and industrial leaders.

Samuel W. Dudley Appointed Dean of Yale School of Engineering

SAMUEL W. DUDLEY, Strathcona Professor of Mechanical Engineering at Yale, has been appointed Dean of the Yale School of Engineering, President James Rowland Angell announced on April 21. He succeeds Dean Robert E. Doherty, who has been elected president of the Carnegie Institute of Technology.

Professor Dudley, who has been chairman of the Department of Mechanical Engineering at Yale since 1923, is one of the outstanding authorities in the application of braking mechanisms to railroad rolling stock equipment, and has played an important part in the development of the air brake. He has also done much original work with the braking equipment on electric rolling stock and high speed streamline trains.

Professor Dudley received his formal scientific training at Yale, where he graduated from the Sheffield Scientific School in 1900, and received the M.E. degree in 1903. He then joined the Westinghouse Air Brake Company at Pittsburgh, Pa., as an engineer, and soon was made local engineer in charge of the installation of electric locomotives and multiple cars on the extensive electrification projects then being undertaken by the New York Central and the New Haven. In 1914 he became chief engineer of the company, and remained in that capacity until 1921, when he was called to Yale to one of the newly established chairs on the foundation provided by the will of Lord Strathcona and the Mount Royal of Canada. The chair was founded in "the interest of modern science, civil and mechanical engineering."

S. W. Dudley

Professor Dudley has taken an active part in transportation engineering as a member of Yale's committee on this subject and in co-operation with the Society for the Promotion of Engineering Education, the railroad division of the American Society of Mechanical Engineers, and the executives and educational directors of the railroads and the supply industry.

British to Build 587 Locomotives

BRITISH railways will build 587 new locomotives in their own shops in the near future, according to a recent announcement. Included will be 17 locomotives which the London & North Eastern will build of a design generally similar to that of its streamline "Silver Link" which now hauls the L.N.E. "Silver Jubilee" train between London & Newcastle. The decision of the L.N.E. in this connection, the announcement says, is "the result of the remarkable success which has attended the working of the existing streamline locomotives. It has been found that the streamlining has saved a great deal of power, in addition to which it has solved the problem of lifting smoke and steam so that it does not obstruct the driver's view. For high speed running at rates in excess of 60 m.p.h. it has also been found that the reduction of wind resistance effected by streamlining has had beneficial effects upon fuel consumption."

Supply Trade Notes

HARRY N. HAYES has been appointed Chicago district manager of the Coffing Hoist Company, Danville, Ill.

THE P. AND M. COMPANY has moved its office from 165 Broadway to 50 Church street, New York.

I. LAMONT HUGHES, executive vice-president and a director of the Carnegie-Illinois Steel Corporation, has resigned.

JOHN C. KEENE has been appointed sales representative of the Illinois Railway Equipment Company, with headquarters at Chicago.

THE NOLAND COMPANY, INC., Washington, D. C. has been appointed Toncan Iron sheet distributors, for the Republic Steel Corporation, Cleveland, Ohio.

SIDNEY E. TREADWELL, representative of the Railway Sales division of The Texas Company, with headquarters at Atlanta, Ga., has been appointed district manager with the same headquarters.

THE ASSOCIATION OF MANUFACTURERS OF CHILLED CAR WHEELS, Chicago, has consolidated its offices with its laboratory and research department and the combined facilities are now located at 445 North Sacramento boulevard.

THE G. M. BASFORD COMPANY, New York, has moved its branch office from 2717 Koppers building, Pittsburgh, Pa., to 422 Leader building, Cleveland, Ohio.

BRAMAN, DOW & CO., Boston, Mass., has been appointed dealer agent in the Boston area for the General Refractories Company, Philadelphia, Pa.

THE ELECTRO-MOTIVE CORPORATION, La-Grange, Ill., has moved its New York office from 10 East Fortieth street to the New York Central building, 230 Park ave.

A. F. DOBBRODT of the Chicago office of the Carboloy Company, Inc., manufacturers of Carboloy cemented carbide cutting tools and dies, has been transfered to 2802 Atkinson avenue, Milwaukee, Wis.

WILLIAM M. ROCHE, formerly vice-president of the Waugh Equipment Company, New York, has been elected vice-president of the International Supply Company, Chicago.

NORBERT E. SMITH, representative of Joseph T. Ryerson & Son, Inc., with headquarters at Indianapolis, Ind., has been appointed sales representative of the Inland Steel Company, with headquarters in Chicago.

THE WROUGHT WASHER MANUFACTURING COMPANY, Milwaukee, Wis., through its Los Angeles sales agents, the Western Washer & Manufacturing Company, is expanding its range of service in California and adjacent territory. The latter company has moved into larger quarters at 2111 East Fifty-first street, Los Angeles.

ROSS F. HAYES has been appointed eastern sales agent of the Railway Utility Company, Chicago, succeeding J. H. Denton, who has represented the company in that territory for the past 23 years. Mr. Hayes will continue his headquarters at 50 Church street, New York.

CHARLES R. SURFACE has been appointed sales manager of the P & H Electric Motor Sales division of the Harnischfeger Corporation, Milwaukee, Wis. Mr. Surface is located in the home office in Milwaukee, and is in charge of sales covering motors and electric plants.

THE REPUBLIC STEEL CORPORATION has appointed the Equitable Equipment Company, Inc., New Orleans, La., distributor of its Enduro stainless steel. The York Corrugating Company, York, Pa., and the Sheet Metal Manufacturing Company, Inc.,

(*Continued on next left-hand page*)

MORE TONNAGE At Higher Speeds and lower Costs

Capacity trains at higher speeds spread operating expense over more ton-miles. » Modern locomotives set the pace—they haul more tons at faster speeds — they reduce ton-mile costs. They speed up the entire railroad and increase net earnings.

LIMA LOCOMOTIVE WORKS INCORPORATED

LIMA LOCOMOTIVE WORKS, INCORPORATED, LIMA, OHIO

Stamford, Conn., have been appointed Toncan Iron sheet distributors. The latter company is a branch of the same firm in Brooklyn, N. Y., which had previously been appointed distributors of Toncan sheets.

C. RUSSELL WARREN, formerly head of the Chicago branch of L. C. Chase & Company, Inc., New York, and with this organization for the past 14 years, has been appointed sales manager for all Goodall-Sanford transportation and home-furnishings divisions at New York.

THE OWEN-DYNETO CORPORATION, Syracuse, N. Y., a subsidiary of Electric Auto-Lite, is now manufacturing and selling USL arc welding equipment. The entire engineering staff and manufacturing machinery and equipment have been moved from Niagara Falls, N. Y., to Syracuse, N. Y. J. L. Fosnight has been appointed sales manager, welder division, Owen-Dyneto Corporation.

HAROLD T. HENRY, who has resigned as eastern district sales manager of the Q & C Company, New York, to become manager of railroad sales of the Burden Iron Company, Troy, N. Y., was

Harold T. Henry

born at Fishkill, N. Y., in 1898, and was educated in high school and later graduated from Morrisville College, Morrisville, N. Y. He served for 16 years with the Q & C Company in various capacities, including inspection work, advertising, shop work and also assisted in the development and sales of several railroad devices both in the mechanical and maintenance departments of the railroads. Previous to that time Mr. Henry was connected with the United States Air Corps test department.

G. M. LAUGHLIN, JR., chairman of the board of the Jones & Laughlin Steel Corporation, has announced his desire to tender his resignation as chairman of the board to take effect upon completion of current financing operations, and it is expected at that time that H. E. Lewis, chairman of the executive committee of the Jeffrey Manufacturing Company, Columbus, Ohio, and formerly executive vice-president of the Bethlehem Steel Corporation, will be elected a director and chairman of the board of the Jones & Laughlin Steel Corporation.

R. A. GRISWOLD, for many years identified with the anti-friction bearing industry, who joined the sales organization of the Bantam Ball Bearing Company, South Bend, Ind., in October, 1935, has been assigned the Connecticut and Massachusetts territory, with headquarters at Hartford, Conn.

THE FOOTE BROS. GEAR & MACHINE CORPORATION has taken over all activities and assets of Foote Bros. Gear & Machine Company, Chicago, completing the reorganization and consolidation of its activities. The officers are as follows: Franklin H. Fowler, president and general manager; W. A. Barr, vice-president in charge of manufacturing; F. A. Emmons, vice-president in charge of sales and J. R. Fagan, secretary and treasurer.

C. W. DIETRICH, JR., has been appointed sales engineer for the Torrington Company, Torrington, Conn, and the Bantam Ball Bearing Company, South Bend, Ind., to handle their bearings and specialties in the New York territory, with headquarters at 200 Fifth avenue, New York. Mr. Dietrich was graduated in mechanical engineering at Cornell University in 1918, and then served in engineering and sales capacities with the Automatic Refrigerating Company, the Hyatt Roller Bearing division of General Motors and the James T. Gordon Company.

WILLIAM O. ASHE, mechanical engineer of the Commonwealth plant of the General Steel Castings Corporation, Granite City, Ill., has been appointed sales engineer, with the same headquarters. From 1906 to 1910, he was employed in the engineering department of the American Locomotive Company at Schenectady, N. Y., and from August, 1910, to April, 1923, was with the New York Central as draftsman, chief draftsman and assistant engineer of motive power. In April, 1923, he was appointed mechanical engineer of the Commonwealth Steel Company and continued in that capacity until 1929, when the Commonwealth Steel Company became a part of the General Steel Castings Corporation. Since then Mr. Ashe has been mechanical engineer of the Commonwealth plant at Granite City.

Obituary

HARRY U. HART, vice-president and chief engineer of the Canadian Westinghouse Company, Ltd., died suddenly at Hamilton, Ontario, on March 15.

WILLIAM CHARLES PEYTON, president of the Standard Stoker Company, Inc., died on April 4 at his home in New York at the age of 67.

MAJOR CHARLES CAROTHERS, formerly representative of the Franklin Railway Supply Company, with headquarters at Chicago, died in that city on March 30 of angina pectoris.

ARTHUR G. JOHNSON, president of the Armspear Manufacturing Company, New York, died on March 21. Mr. Johnson was in his fifty-second year and had been connected with the Armspear company for 15 years.

WILLIAM A. FORBES, vice-president of the United States Steel Corporation, died on April 7 at Doctors Hospital, New York.

CLARENCE J. OLMSTEAD, who retired in 1931 as assistant to the president of the Westinghouse Air Brake Company, died at Miami, Fla., on March 23.

GEORGE G. CRAWFORD, who retired as president of the Jones & Laughlin Steel Corporation in May, 1934, and who was president of the Tennessee Coal, Iron & Railroad Company prior to 1930, died in Birmingham, Ala., on March 20.

CHARLES S. LOCKWOOD, who worked with John W. Hyatt on the invention of the Hyatt roller bearing, died in Newark, N. J., on March 20, in his eighty-sixth year. Mr. Lockwood was an active member of the Hyatt experimental laboratory staff almost up to the time of his death, his career having covered 62 years in the service. More than 44 of these years were devoted to the Hyatt Roller Bearing Company, since its incorporation in 1892. Mr. Lockwood himself took out nearly 100 patents.

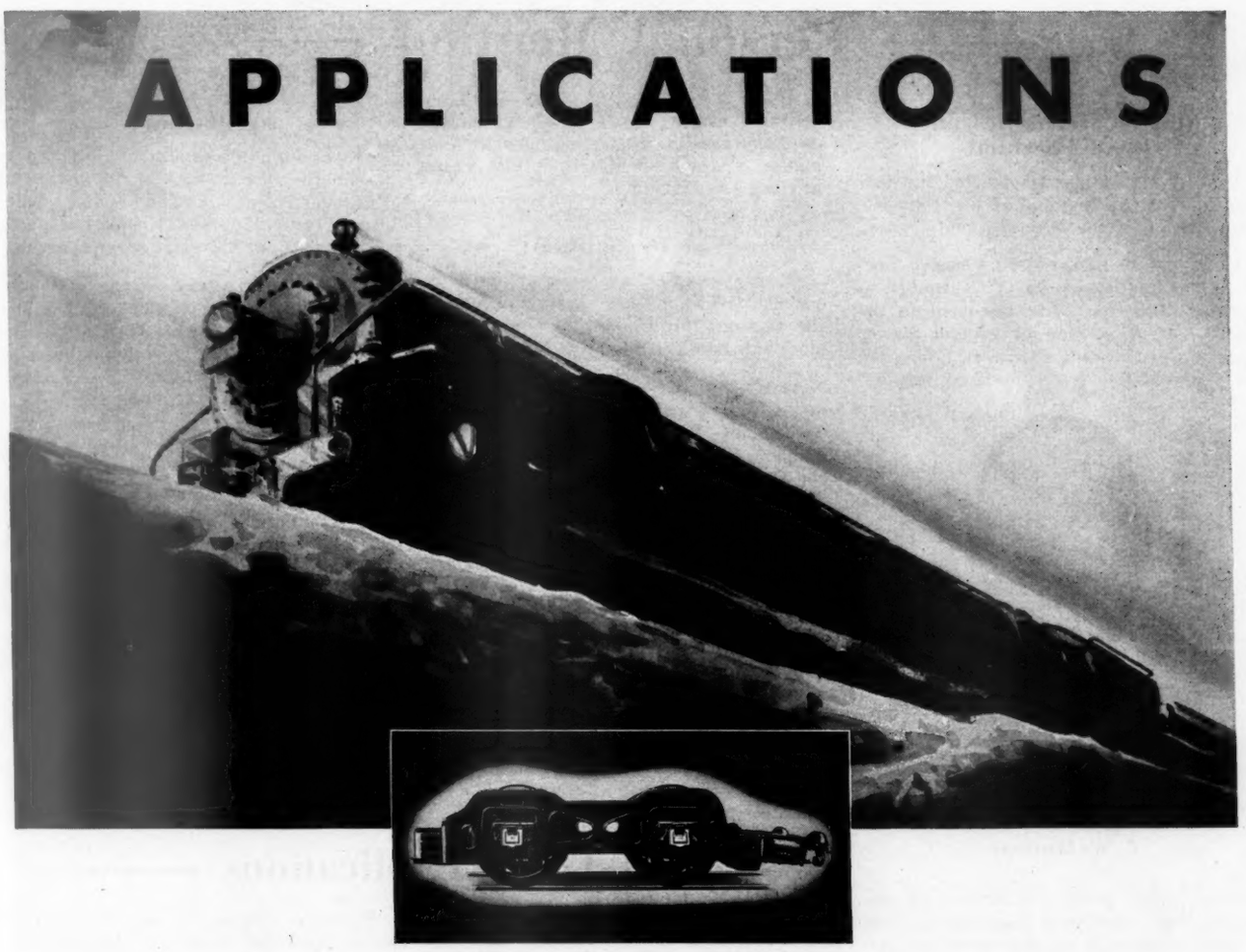
CHARLES D. JENKS, president of the Chicago-Cleveland Car Roofing Company, died in San Francisco, Cal., on April 14, following a month's illness. Mr. Jenks was born in Philadelphia, Pa. He was employed in the freight and operating de-

Charles D. Jenks

partments of the Pennsylvania at Philadelphia for nine years and then entered the employ of the Atlantic Refining Company, Philadelphia, in the engineering and construction department. In 1900, he became assistant to the vice-president of the Pressed Steel Car Company, with headquarters at Pittsburgh, Pa., and later was promoted to sales agent, with headquarters at Chicago. In 1910 he was appointed western sales manager of the Standard Coupler Company, with headquarters at Chicago; from 1912, to January 31, 1918, was general manager of Edwin S. Woods & Co., and from the latter date until February 28, 1923, was president and a director of the Damascus Brake Beam Company at Cleveland, Ohio. He then became vice-president of the Chicago-Cleveland Car Roofing Company at Chicago, and in 1925, was elected president.

(Turn to next left-hand page)

APPLICATIONS



DICTATED BY EXPERIENCE!

During the first two months of 1936 there were 50 new locomotives ordered. Eleven were switchers, twenty were mallets and 19 for passenger and freight train service.

Of the latter nineteen locomotives suitable for Booster application, seventeen were equipped with The Locomotive Booster.

These applications were all made by railroads having a previous wide experience with the advantages and maintenance economies that The Locomotive Booster brings.

Booster Repair Parts made by the jigs and fixtures that produced the original are your best guarantee of satisfactory performance.

FRANKLIN RAILWAY SUPPLY COMPANY, INC.

NEW YORK CHICAGO MONTREAL

Personal Mention

Master Mechanics and Road Foremen

J. W. WEST has been appointed assistant road foreman of engines of the Philadelphia division of the Pennsylvania.

CHARLES W. MATHEWS, master mechanic of the Louisville & Nashville at Decatur, Ala., has been appointed to the newly created position of general master mechanic, with headquarters at Louisville, Ky. Mr. Mathews was born on July 14, 1884, at Lyons, Mich. He entered the employ of the Louisville & Nashville on June 3, 1900, completing his apprenticeship and serving as a machinist at Decatur until May 12, 1904. From that date until June 19, 1905, he was consecutively in the employ of the Nashville, Chattanooga & St. Louis at Nashville, Tenn., the Tennessee, Central at Nashville, and the Alabama Great Southern at Birmingham, Ala., as a machinist. He then returned to the Louisville & Nashville and until May 28, 1907, was a machinist and foreman, Birmingham District. From May 28, 1907, to January 23, 1908, he was machinist and assistant night enginehouse foreman of the Alabama Great Southern at Birmingham. On the latter date he became enginehouse foreman of the Louisville & Nashville at Boyles, Ala.; on May 3, 1913, general foreman at Anniston, Ala.; on May 31, 1917, assistant master mechanic at Covington; on April 1, 1918, master mechanic at Covington, Ky., and on March 1, 1919, master mechanic at Decatur.

C. W. Matthews

Car Department

H. A. GROPHE, has been appointed assistant passenger shop superintendent of the Chicago, Milwaukee, St. Paul & Pacific with headquarters at Milwaukee, Wis.

A. C. SCHROEDER, production inspector in the car department of the Chicago, Milwaukee, St. Paul & Pacific, has been appointed general foreman of the freight car shop at Milwaukee, Wis.

L. E. HILSABECK, car foreman on the Chicago Great Western at Oelwein, Iowa, has been appointed to the newly-created position of general car inspector of freight and passenger equipment, with headquarters at Oelwein.

Shop and Enginehouse

A. R. CARSON, assistant superintendent motive power shops of the Canadian National at Moncton, N. B., has been appointed superintendent of shops.

Obituary

J. E. INGLING, supervisor of fuel and locomotive operations for the Erie, with headquarters at Cleveland, Ohio, died on April 14 at Paterson Hospital, Paterson, N. J., after an illness of several weeks.

HUGH MONTGOMERY, former superintendent of motive power and rolling stock of the Rutland, with headquarters at Rutland, Vt., who died recently of heart disease, at Cocoanut Grove Fla., was born on April 26, 1864, at London, Ont., and received his education in the public schools. Mr. Montgomery entered railway service in 1879 as an apprentice on the Canada Southern (Michigan Central) and in 1884 he became locomotive fireman of the Chicago & North Western, serving consecutively as engineman, road foreman of engines and general foreman. In 1900 he was appointed road foreman of engines and later general foreman of the Central of New Jersey. In 1907 he became superintendent motive power and equipment of the Bangor & Aroostook. Mr. Montgomery was appointed superintendent motive power and rolling stock of the Rutland in July, 1913, from which position he retired in the latter part of last year.

Trade Publications

Copies of trade publications described in the column can be obtained by writing to the manufacturers. State the name and number of the bulletin or catalog desired, when mentioned in the description.

DIE HEADS.—The Eastern Machine Screw Corporation, New Haven, Conn., describes in a four-page bulletin H & G insert chaser die heads for use on Brown & Sharpe automatic screw machines.

UTILITY JACK.—Acco utility Jack No. 35, suitable for applications involving stretching, pulling, binding or lifting, is described in a four-page bulletin issued by the American Chain Company, Inc., Bridgeport, Conn.

PLICOTE.—Plicote, a scientifically prepared protective covering of a paint-like nature for application to metal, concrete, wood, etc., is described in a booklet issued by the Watson-Standard Company, Pittsburgh, Pa.

HICYCLE TOOLS.—Catalog No. 900, issued by the Chicago Pneumatic Tool Company, 6 East Forty-Fourth street, New York, covers a new line of Hicycle portable electric tools, including drills, screw drivers, nut runners, grinders and sanders.

PIPE THREADING AND CUTTING-OFF MACHINE.—Bulletin No. C-82 featuring the Little Landis pipe threading and cutting off machine has been issued by the Landis Machine Company, Waynesboro, Pa. This machine employs both the Landis die head and the Landis long life chaser.

MARINAC'S RAIL ODDITIES

MARINAC has furnished us with the following explanations of the three cartoons which appear elsewhere in this issue.

Page 204. Not so many years ago, before the use of electricity became common, gas lamps were used for street lighting. Promptly at twilight the gas lighter would make his rounds, many of them riding bicycles. In Kent, England, the system used by W. H. Slater, a retired naval officer, whose duty it is to light the riverside wharf lamps, recalls this old custom. Instead of using a bicycle for his five-mile trip, he has constructed a novel land yacht, and sails to his work over steel rails.

Page 212. Some of the early American railroads adopted the English practice of running trains on the left-hand side, where double tracking was used. This practice has now been changed on most roads in this country, but the Chicago & North Western still adheres to it. A heavy expenditure would be necessary to change to the right-hand side, and in addition the British practice is said to possess some distinct advantages.

Page 221. Speed—fastest thing on wheels. It made a forgotten world's record. This little streamline electric locomotive made the incredible speed of 120 miles an hour in 1889. It was designed to haul freight from New York to San Francisco in 24 hours, but an accident during a test run sent it to the Smithsonian Institution, where it has lain ever since, rusting and forgotten. The recent introduction of streamline, articulated trains caused patent attorneys to check back over the files. They discovered that the basic idea had been patented 70 years ago; it was merely ahead of its time! More recently, a general stock taking of the contents of the lumber rooms of the Smithsonian Institution, at Washington, disclosed the original of the high speed electric train.